ELEMENTS

OF

CHEMISTRY.

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ELEMENTS

OF

CHEMISTRY.

PART THE SECOND.

CONCERNING LITHOLOGY; OR AN ACCOUNT OF STONY SUBSTANCES.

INTRODUCTION.

THE object of Lithology consists in the study of stones and earths.

It is generally agreed to call those substances by the name of Earth or Stone, which are dry, brittle, inodorous, insipid, scarcely or not at all soluble in water, and of a specific gravity not exceeding 4,5.

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There is no one who has seriously attended to the study of lithology, without being at the same time aware of the necessity of establishing divisions to facilitate the knowledge of stones, and to remove the numberless difficulties which would otherwise oppose the acquisition of that knowledge.

It is an obvious difference between living creatures and the subjects of the mineral kingdom, that these last are continually modified by external causes, such as air, water, fire, &c. while the former, being animated and governed by an internal force, possess characters of a more definite and unchangeable nature. The forms of these depend upon their organization; and, in general, the proceedings of nature respecting them are more constant, and better ascertained.

The earthy element appears to be passive of itself: it is obedient only to the laws of inanimate bodies; and we may refer all the phenomena of formation or decomposition, which a stone is susceptible of, to the mere law of affinities. This, no doubt, is the cause of that variety of forms, and that mixture of principles, which scarcely permit the naturalist to establish his system upon fixed bases, or to found it upon constant and invariable characters.

If we take a view of the proceedings of all the naturalifts who have hitherto written, we may eafily reduce them to three claffes.

1. The firft clafs, carried by the imagination alone to that epocha when this globe iffued from the hands of the Creator, have followed the actions of the various deftructive agents which alter or overturn its furface. In this way they have fhewn us the various rocks fucceffively depofited or placed upon the primitive globe; and, by furveying the great phenomena which have happened upon our planet, they have acquired ideas more or lefs accurate refpecting the vaft works of decompofition and formation.

2. Others have bufied themfelves in enquiring, by analyfis, what are the earths or primitive matters out of which all the ftones we are acquainted with are compofed. This clafs of philofophers have fupplied us with the moft valuable acquifitions refpecting the nature, the ufes, and the decompofitions of thefe fubftances: but the refults of analyfis, though neceffary in acquiring accurate notions of each ftone, are not of themfelves fufficient to form the bafis of a method of claffing; becaufe thefe characters are too difficult to be acquired, and at moft can be ufed only as fupplementary in the eftablifhment of fuch other methods as may be employed.

3. Almoſt all the ſyſtems of claſſification hitherto adopted, are founded upon the external characters of earthy ſubſtances.

Some naturaliſts have ſought, in the variety of forms exhibited by the productions of the mineral kingdom, ſuch principles of diviſion as to them appeared ſufficient. But not to mention that the ſame form frequently obtains in very different ſtones, this character is rarely found, and we are ignorant of the cryſtallization of moſt of the known earths: the cryſtallization cannot therefore be conſidered but as an acceſſary or ſecondary circumſtance.

Other naturaliſts have eſtabliſhed their diviſions upon certain properties eaſy to be aſcertained, ſuch as that of effervеſcing with acids, giving fire with the ſteel, &c. But theſe characters do not appear to be ſufficiently ſtrict, nor ſufficiently excluſive; for nothing is more common than to find a mixture of the fragments of primitive rocks with thoſe of calcareous ſtones. Our province exhibits examples of this every ſtep we take; and theſe mixtures, hardened by time, poſſeſs both the before-mentioned characters. There are alſo ſtones which, without changing their nature, give fire with the ſteel, or effervеſce with acids, accordingly as they are more or leſs divided. Such is the lapis lazuli,

lazuli, which effervefces when pulverized, but ftrikes fire when in the mafs; the flate likewife effervefces when in powder, but not in the mafs. The claffification, therefore, which is founded on thefe characters, is not rigorous, and they may at the moft be made ufe of in conjunction with others.

M. D'Aubenton is the naturalift who appears to me to have diftributed mineral fubftances with the greateft order of any who has hitherto undertaken that tafk: every thing which he fays on this fubject fhews the experienced eye of the obferver; and he has drawn from the external characters of bodies all the characters poffible to be had from that fource. But he could not avoid the defects which neceffarily accompany the principles on which he has founded his fyftem.

Deeply impreffed with a fenfe of the infufficiency of thefe methods, as well as of the flight opportunities I have poffeffed of improving them, my endeavours have been exerted in collecting together all the characters which are capable of affording any ufeful indications. In this purfuit, I have joined the characters of the naturalift to thofe of the chemift; and though the method which I have adopted be very far from that degree of perfection which might be

 defired,

deſired, I nevertheleſs preſent it to the public with confidence. It differs but little from that followed by Meſſrs. Bergmann and Kirwan; a circumſtance which at leaſt affords a prejudice in its favour. The peculiar advantages which, in my opinion, it appears to poſſeſs, are—1. The lithologic productions are diſtributed equally, and into three claſſes. 2. All the analogous productions are brought together, and arranged as it were in a natural order. In a word, this ſyſtem has fixed my own ideas in the moſt preciſe manner; and this has more particularly induced me to propoſe it to the public*.

The

* I conſider what is here publiſhed reſpecting Lithology as a ſimple and ſhort ſketch of the principles which I explain in my Lectures. It would be judging me with too much ſeverity, if the reader were to ſuppoſe that my preſent deſign is to exhibit a complete performance.

A more intimate acquaintance with this ſubject may be obtained by the peruſal of the following works:

1. Eſſai d'un Art de Fuſion, à l'Aide de l'Air Vital, par Erhmann.—Mémoires de M. Lavoiſier ſur le même ſujet.—Mémoires de M. D'Arcet, ſur l'Action d'un Feu égal, violent, et continu, ſur un grand nombre de Terres, Pierres, &c.

2. The Works of Margraff and Pott, more eſpecially the Lithogeogneſia of the latter.

3. Les Peſanteurs Spécifiques des Corps, par M. Briſſon.

4. Elements of Mineralogy, by Mr. Kirwan.

5. Le Manuel du Minéralogiſte de Bergmann, enrichi de Notes par M. l'abbé Mongez.

6. La

The various earths beneath our feet are, in general, combinations; and chemiſts, by decompoſing theſe ſubſtances, have ſucceeded in obtaining, in the laſt analyſis, principles which may be conſidered as earthy elements, until ſubſequent acquiſitions ſhall either confirm or deſtroy our ideas on this ſubject.

The earthy elements moſt extenſively diſtributed are five in number; namely, Lime, Magneſia, Barytes, Alumine, and Silex.

We ſhall not treat of the other primitive earths announced by Mr. Klaproth, in the adamantine ſpar, and in the jargon of Ceylon, becauſe they are yet too ſlightly known, and too ſcarce, to have any influence upon our preſent diviſion.

6. La Minéralogie de M. Sage.

7. Les Ouvrages ſur la Cryſtallographie de M. de Romé de Liſle, de M. l'abbé Hauy, &c.

8. Le Tableau Méthodique des Minéraux, par M. D'Aubenton.

9. La Minéralogie de M. le Comte de Buffon; in which that celebrated writer has collected a great number of valuable facts, whoſe merit is independent of all theory.

10. The Mineralogical Works of Meſſrs. Jars, Dietrich, de Born, Ferber, Trebra, Pallas, Cmelin, Linné, Dolomieu de Sauſſure de la Peyrouſe, &c.

11. The excellent Analyſes of Stones, publiſhed from time to time by Pott, Margraff, Bayen, Bergmann, Gerard, Scheele, Achard, Mongez, &c.

Nature appears to have formed all the mixtures and combinations which conſtitute ſtones, out of the primitive earths here ſpoken of.

If we direct our attention to the nature of theſe mixtures and combinations, we ſhall diſtinguiſh three habitudes, or modes, which eſtabliſh three grand diviſions. We ſhall immediately perceive that theſe earths are, in ſome inſtances, combined with acids, which form ſaline ſtones; that in other inſtances they are mixed with each other, and form ſtones properly ſo called; and that in other inſtances, again, theſe ſtones, ſo formed by the mixture of primitive earths, are united together, or fixed in a gluten or cement, which forms rocks, pebbles, or compound ſtones.

We ſhall therefore diſtinguiſh three claſſes in Lithology: the firſt will comprehend ſaline ſtones; the ſecond ſtones, properly ſo called, or earthy mixtures; and the third rocks, or ſtony admixtures.

We conſider it as indiſpenſably neceſſary to explain the nature of the primitive earths, before we can proceed to treat of their combinations.

I. Lime.

This earth has been found totally difengaged from all combination, near Bath.—See Falconer on the Bath Waters, vol. i. page 156 and 157. But as this is perhaps the only obfervation of the kind which we poffefs, it is indifpenfably neceffary to fhew the procefs by which lime may be obtained in a ftate of the greateft purity.

For this purpofe chalk is to be wafhed in boiling diftilled water, then diffolved in diftilled acetous acid, and precipitated by the carbonate of ammoniac, or mild volatile alkali. The precipitate, being wafhed and calcined, is pure lime.

This earth poffeffes the following characters:

1. It is foluble in fix hundred and eighty times its weight of water, at the temperature of fixty degrees of Fahrenheit. Kirwan.

2. It has a penetrating, acrid, and burning tafte.

3. Its fpecific gravity is about 2,3 according to Kirwan, and 2,720 according to Bergmann.

4. It feizes water with great avidity; at the fame time that it falls into powder, increafes in bulk, and emits heat.

5. Acids diſſolve it without efferveſcence, but with the production of heat.

6. The borate of ſoda, or borax, the oxides of lead, and the phoſphates of urine, diſſolve it by the blow-pipe without efferveſcence.

It appears to be infuſible alone, as it has reſiſted the heat of flame urged by a ſtream of vital air.—See the Memoir of Mr. Lavoiſier.

When it is mixed with acids, it forms a fuſible combination; and it haſtens the fuſion of aluminous, ſiliceous, and magneſian earths, according to the experiments of Meſſrs. Darcet and Bergmann.

II. Barytes, or Ponderous Earth.

We are indebted to the celebrated chemiſts Gahn, Scheele, and Bergmann for our knowledge of this earth.

It has not yet been found exempted from all combination; but in order to obtain it in a ſuitable degree of purity, the following proceſs may be uſed:

The ſulphate of barytes, or ponderous ſpar, which is the moſt uſual combination met with on the earth, is to be pulverized, and calcined in a crucible, with an eighth part of powder of charcoal: the crucible muſt be kept ignited during an hour; after which the calcined matter is to be

thrown

thrown into water: it communicates a yellow colour to this fluid, at the ſame time that a ſtrong ſmell of hepatic gas is emitted; the water is then to be filtered, and muriatic acid poured in: a conſiderable precipitate falls down, which muſt be ſeparated from the fluid by filtration. The water which paſſes through the filter holds the muriate of barytes, or marine ſalt of ponderous earth, in ſolution. The carbonate of pot-aſh, or mild vegetable alkali, in ſolution, being then added, the ponderous earth falls down, in combination with the carbonic acid; and this laſt principle may be driven off by calcination.

1. Pure barytes is of a pulverulent form, and extremely white.

2. It is ſoluble in about nine hundred times its weight of diſtilled water, at the temperature of ſixty degrees, according to Kirwan.

3. The Pruſſiate of pot-aſh, or Pruſſian alkali, precipitates it from its combination with the nitric and muriatic acids. This habitude diſtinguiſhes it from other earths.—See Kirwan.

4. It precipitates alkalis from their combinations with acids.

5. Barytes expoſed, by Mr. Lavoiſier, to flame fed with oxigenous gas, was fuſed in a few

 ſeconds:

feconds: it extended itfelf upon the furface of the coal; after which it began to burn and detonate until the whole was nearly diffipated. This kind of inflammation is a character common to metallic fubftances; but when the barytes is pure it is perfectly infufible.—See Lavoifier.

Ponderous earth urged by the blow-pipe makes little effervefcence with foda, but is perceptibly diminifhed: it diffolves in the borate of foda with effervefcence, and ftill more with the phofphates of urine.—See the abbé Mongez' Manuel du Minéralogifte.

6. Its fpecific gravity exceeds 4,000, according to Kirwan.

III. Magnefia, or Magnefian Earth.

This earth has been nowhere found difengaged from all foreign fubftances; but in order to obtain it in the utmoft poffible ftate of purity, the cryftals of the fulphate of magnefia, or Epfom falt, are to be diffolved in diftilled water, and decompofed by the carbonate of alkali. The precipitate muft then be calcined, to difengage the carbonic acid.

1. Pure magnefia is very white, very friable, and, as it were, fpongy.

2. Its fpecific gravity is about 2,33, according to Kirwan.

3. It is not perceptibly foluble in water when pure;

pure; but when it is combined with the carbonic acid, it is ſoluble; and cold water has a ſtronger action on it than hot, according to the experiments of Mr. Butini.

4. It has no perceptible action on the tongue.

5. It ſlightly converts the tincture of turnſole to a green.

6. Mr. Darcet has obſerved, that a ſtrong heat agglutinates it more or leſs; but Meſſrs. De Morveau, Butini, and Kirwan, found that it was not fuſible; and the experiments of Mr. Lavoiſier have proved that it is as infuſible as barytes and lime.

The borate of ſoda, and the phoſphates of urine, diſſolve it with effervefcence.—See the abbé Mongez.

IV. Alumine, or Pure Clay.

This earth is not more exempt from mixture and combination than the foregoing; and in order to obtain it in a ſtate of purity, the ſulphate of alumine is diſſolved in water, and decompoſed by effervefcent alkalis.

1. Pure clay ſeizes water with avidity, and may then be kneaded. It adheres ſtrongly to the tongue.

2. Its ſpecific gravity does not exceed 2,000, according to Kirwan.

3. When expoſed to heat, it dries, contracts,

ſhrinks, and becomes full of clefts. A conſiderable degree of heat renders it ſo hard that it gives fire with the ſteel.

When it has been well baked, it is no longer capable of uniting with water; but requires to be diſſolved in an acid, and precipitated, in order that it may reſume this property.

The experiments of Mr. Lavoiſier ſhew that pure alumine is capable of an imperfect fuſion, approaching to the conſiſtence of paſte, by heat excited by a current of vital air. It is then transformed into a kind of very hard ſtone, which cuts glaſs like the precious ſtones, and which very difficultly yields to the file.

The mixture of chalk ſingularly aſſiſts the fuſion of this earth: it is fuſible in a crucible of chalk, according to Mr. Gerhard, but not in a crucible of clay.

The borate of ſoda, and the phoſphates of lime, diſſolve it.—See Kirwan and the abbé Mongez.

According to the experiments of Mr. Dorthes, the pureſt native clays, and even that which is precipitated from alum, contain a ſmall quantity of iron in the ſtate of oxide; and it is from this principle that the earthy ſmell which is emitted by moiſtened clays, ariſes: it is very difficult to deprive them of it.

V. Silex

V. Silex, or Quartzose Earth, Vitrifiable Earth, &c.

This earth exifts nearly in a ftate of purity in rock cryftal. But when it is required to be had in a ftate of purity free from all fufpicion, one part of fine rock cryftal may be fufed with four of pure alkali. The fufed mafs muft then be diffolved in water, and precipitated by an excefs of acid.

1. Pure filex poffeffes a fingular degree of roughnefs and afperity to the touch. It is abfolutely void of all difpofition to adhere; and its particles, when agitated in water, fall down with extreme facility.

2. Its fpecific gravity is 2,65.

3. Bergmann had affirmed that water might diffolve it; and Mr. Kirwan has pretended that 10,000 parts of water might hold one of filex in folution, at the ordinary temperature of the atmofphere; and might even take up a greater quantity at a higher temperature.

The fluoric acid diffolves it; and lets it fall when it comes in contact with water, or when it is confiderably cooled.

5. Alkalis diffolve it in the dry way, and form glafs; but they attack it likewife in the humid way, and are capable of diffolving one-fixth part

part of their weight when it is in a ſtate of extreme diviſion.

6. The burning mirror does not fuſe it; but a current of vital air produced a commencement of fuſion on its ſurface.—See Lavoiſier.

Before the blow-pipe ſoda diſſolves it with effervеſcence. The borate of ſoda diſſolves it ſlowly, and without ebullition.

CLASS I.

Concerning the Combination of Earths with Acids.

This claſs, which comprehends the combination of primitive earths with acids, naturally exhibits five genera.

GENUS I.

Earthy Salts with Baſis of Lime.

The combination of lime with various acids affords the ſeveral ſpecies of calcareous ſalts comprehended in this genus.

SPECIES I.

Carbonate of Lime, or Calcareous Stone.

The combination of lime with the carbonic

acid

acid is very commonly met with, and comprehends all the ſtones which have hitherto been diſtinguiſhed under the names of lime-ſtone, calcareous ſtone, &c.

The character of the carbonates of lime are— 1. They effervefce with certain acids. 2. They are converted into lime by calcination.

The formation of theſe ſtones appears to us to be, for the moſt part, owing to the wearing down of ſhells. The identity of the conſtituent principles of ſhells and calcareous ſtones, and the preſence of theſe ſame ſhells, more or leſs altered, in the lime-ſtone mountains, authorize us to conclude that a great part at leaſt of the calcareous maſs of our globe owes its origin to this cauſe only.

Though our imagination appears to aſſent with difficulty in referring effects of ſo wonderfully extenſive a nature to a cauſe apparently ſo weak, we are compelled to admit it when we take a ſlight view of the known hiſtory of ſhells.

In fact, we obſerve the numerous claſs of ſhell animals which poſſeſs this ſtony covering almoſt at the inſtant of their origin. We ſee it inſenſibly become thick and enlarged by the appoſition of new coverings; and this ſhell at length comes to occupy a volume fifty or ſixty times larger than that of the animal which pro-

duced it. Let us confider the prodigious number of animals which emit this ftony tranfudation; let us attend to their fpeedy augmentation, their multiplication, and the fhort period of their life, the mean term of which is about ten years, according to the calculation of the celebrated Buffon; let us multiply the number of thefe animals by the mafs of fhell they leave behind them—and we fhall then arrive at the mafs which the fhells of one fingle generation ought to form upon this globe. If we proceed further to confider how many generations are extinct, and how many fpecies are loft, we fhall be no longer furprifed to find that a confiderable part of the furface of the globe is covered with their remains.

It may eafily be conceived that thefe fhells, when carried along by currents of water, muft ftrike together, and wear their refpective furfaces; and that their pulverulent remains, after being long carried about and fufpended by the waters, muft at laft fubfide, and form heaps or banks of fhells, more or lefs altered according to circumftances.

But whatever may be admitted as the origin of this ftone, it is found to exift in two principal ftates; that is to fay, either in the form of cryftals, or of irregular maffes.

I. Cryf-

I. Cryſtallized Calcareous Stones.

A concurrence of circumſtances which very ſeldom meet together, is required, in order that cryſtallization may take place. This is, doubtleſs, the reaſon why ſpars and calcareous cryſtals compoſe the ſmalleſt part of this genus. Theſe cryſtals are found in the cavities of calcareous mountains; in the clefts which penetrate into the internal part of ſtones of this claſs; and generally in all places where waters find acceſs, after having worn down calcareous ſtone to a ſtate of extreme attenuation, nearly correſpondent to ſolution.

Calcareous ſtone, in its cryſtallized ſtate, preſents us with ſeveral varieties of form; but the rhomboidal figure appears to be the moſt conſtant and the moſt general. The environs of Alais abound with rhomboidal ſpars of the greateſt beauty; they are tranſparent like thoſe of Iceland, and double objects in the ſame manner.

It often happens that a group of rhomboidal cryſtals exhibits at its ſurface a number of pyramids more or leſs prominent, which conſiſt of the angles of rhomboids of different degrees of length. It cannot but be admitted, with Mr. Romé de Liſle, that the pyramidal form is a ſlight modification of the rhomboid; for if a pyramid of ſpar be broken, it is reduced into elements of a rhomboidal figure.

The principal varieties of the pyramidal form are deduced more eſpecially from the number of their ſides ; and when the pyramid is long and ſharp, it is called dog-tooth ſpar, or hog-tooth ſpar.

Calcareous ſtones often affect the priſmatic form; and this is likewiſe attended with ſome varieties.

The priſm is frequently ſix-ſided and truncated; ſometimes it is terminated by a trihedral pyramid; and when the priſm is very ſhort, and its ſummit is almoſt entirely in contact with the ground, the cryſtal is known by the name of Lenticular Spar.

All the varieties of form which cryſtallized calcareous ſtones have hitherto preſented, may be ſeen in the Cryſtallography of Mr. Romé de Liſle.

The ſpecific gravity of calcareous ſpars is about 2.700 when pure, according to Kirwan.

They contain from thirty-four to thirty-ſix parts of carbonic acid, and from fifty-three to fifty-five of earth; the reſt is water.—See Kirwan.

Spars often exhibit a ſmooth uniform ſurface, upon which the ſulphuric acid takes but ſlight hold. they are ſometimes contaminated with iron, which gives them various tinges.

II. Calca-

II. Calcareous Stones which are not cryſtallized.

Few calcareous ſtones affect any regular form: they lie almoſt always in ſtrata, or immenſe blocks thrown or heaped together on the ſurface of the globe, in which we cannot reaſonably pretend to diſcern any primitive deſign of cryſtallization. The notion itſelf which we have of the formation of theſe mountains, and the ſtratified diſpoſition of their parts, does not allow us to diſcern any other effect than the natural conſequence of the flowing of water, which muſt have occaſioned a contraction, and diſpoſed the rocks in ſtrata or beds.

It ſeems to me that two very natural diviſions may be eſtabliſhed among calcareous ſtones which are not cryſtallized: for they are either ſuſceptible of a perfect poliſh, in which caſe they are called marbles and alabaſters; or they are not ſuſceptible of this poliſh, in which caſe they are called friable earths, tufa, &c.

A. Calcareous ſtones ſuſceptible of a perfect poliſh.

Although it be proved from the experiments of chemiſts, and more eſpecially from thoſe of Mr. Bayen, that marbles contain a greater or leſs proportion of clay, we are under the neceſſity of placing them here; becauſe the calcareous earth predominates to ſuch a degree, that they

cannot with propriety be placed elſewhere; and becauſe they poſſeſs all the characters of lime-ſtone.

Marbles differ from other calcareous ſtones by the poliſh of which they are ſuſceptible; and they are diſtinguiſhed from each other by their colours.

White marble is uſually the pureſt. We are acquainted with the marble of Carrara, and the ancient ſtatuary-marble of Paros.

Black marble is coloured either by a bitumen or by iron. Mr. Bayen found this metal in the proportion of five parts in the hundred. When it is veined by pyrites, it is called Portor.

There are an infinite number of varieties of coloured marble. The colouring part is in general owing to the alterations of the iron, which ſometimes is obedient to the magnet, according to an obſervation of Mr. De Liſle. Blue and green marbles owe their colours to a mixture of ſchorle, according to Rinmann in his Hiſtory of Iron.

The marble which preſents the figure of ſhells appears to be formed ſimply out of a heap of ſhells connected by a calcareous cement; it is known by the name of Lumachello. That of Bleyberg in Carinthia forms one of the moſt beautiful ſpecies.

The

The marble which is called figured marble, exhibits either traces of vegetables, as that of Heſſe; or ruins and rocks, like that of Florence. The dendrites appear to be formed merely by ferruginous infiltrations through the cracks of theſe ſtones.

Several naturaliſts have mentioned flexible marble. Father Jacquier deſcribed this in 1764, in the Gazette Littéraire; and the abbé De Sauvages has communicated to the Academy of Montpellier a deſcription of the plates of flexible marble which are in the Palais Bourgeois.

Alabaſters are calcareous ſtones of the nature of marble: they appear to be formed like the ſtalactites, and are ſometimes adorned with the moſt beautiful colours: theſe in general poſſeſs a certain tranſparency, with a ſtratiform texture variouſly coloured, and cauſe a double refraction of the light when they are ſufficiently tranſparent. In the treatiſe of Mr. Briſſon on the ſpecific gravities of bodies, the reader will find the reſult of his valuable experiments on that of marbles, alabaſters, and generally all the calcareous ſtones.

B. Calcareous ſtones not ſuſceptible of a perfect poliſh.

Calcareous ſtones which are not ſuſceptible of a per-

a perfect polish, are found either in masses, or in the pulverulent form; which circumstance will afford a foundation for our natural distinction.

1. Solid calcareous stone is in general the stone used for building; and this is found in several varieties, differing in fineness of grain, porosity, colour, consistence, or weight. These are gradations which establish the several qualities of stones; and are the cause why one hardens in the air, while another is decomposed. On these several accounts it is that the respective varieties are applied to various uses; and it is the business of the skilful artist who uses them to distinguish their qualities.

In the number of these stones used for building, there are some which imbibe and retain water, in consequence of which they are burst or crumbled by the frost; whereas others suffer the water which they originally contained to escape, and become harder by the contact of the air.

2. Calcareous stone is sometimes found in the pulverulent form. Chalk is of this kind; and when it is white, and very finely divided, it is formed into those masses known in commerce by the name of Spanish White. For this purpose it is agitated in a vessel with water. The foreign sub-

ſubſtances, ſuch as flints, pyrites, &c. are precipitated; the water is then decanted; and the chalk, which is held ſuſpended, very ſoon ſubſides: this is dried, and divided into long ſquare pieces, to form the Spaniſh White.

When a natural ſtream of water wears away this chalk, and afterwards depoſits it, the reſult has been diſtinguiſhed by the name of Gurrh; and when this poſſeſſes a certain conſiſtence, ariſing from the mixture of argillaceous and magneſian earths, it is diſtinguiſhed by the name of Agaric Mineral.

As calcareous earth is ſuſceptible of extreme diviſion, the water which wears it away, and is afterwards filtered through the clefts in rocks, depoſits it gradually, and forms thoſe incruſtations known by the vulgar under the name of Petrifactions, and by that of Stalactites among naturaliſts.

Theſe calcareous depoſitions very frequently preſerve the form of ſuch ſubſtances as they have covered, and preſent figures of moſs, roots, fruit, &c. which has given riſe to an opinion that thoſe ſubſtances were transformed into ſtone.

The increaſe of ſtalactites being accompliſhed by addition to their external ſurfaces, their texture exhibits concentric coats of different ſhades,

ſhades, accordingly as the water may have been charged with different colouring principles.

The cavities which are frequently found in calcareous mountains are often lined with ſtalactites; and theſe grottos form one of the moſt ſtriking appearances which can preſent itſelf to the eyes of the naturaliſt.

The grandeur of theſe ſubterraneous places, the abſence of light, the feeble glimmering of a torch, which only half enlightens the ſurrounding objects, render theſe regions gloomy, majeſtic, and impoſing. The multiplicity of figures, the variety of forms, and their reſemblance to other objects, never fail to cauſe a high degree of aſtoniſhment in the mind of the mineralogical ſtudent. Among the infinite number of theſe forms, there are ſome which are very agreeable, ſuch as the flos ferri, cauliflowers, lace, or fringes. Other very ſingular figures are likewiſe found, ſuch as the priapolithes, piſolithes, oolithes, &c.

Mr. Lougeon of Ganges has obſerved, in the grotto called Des Demoiſelles, a number of forms ſo varied and ſtrange, as to exhibit a very aſtoniſhing collection.

Theſe tranſudations, or rather theſe ſtony depoſitions, have given riſe to a belief in the vegetation of ſtones. The celebrated Tournefort

was of opinion that he had obſerved nature in the very fact, in the famous grotto of Antiparos, where he ſaw inſcriptions engraved in the ſtone, but afterwards converted into relief. Baglivi has written a treatiſe on the vegetation of ſtones, in which he cites many facts of this nature.

All the world is acquainted with the depoſitions of the ſpring in the vicinity of Clermont; but the moſt ſurpriſing of all petrifying waters is that of Guancavelica in Peru. Barba, D. Ulloa, and Frezier, have given us a deſcription of it. Feuille informs us that this water riſes very hot in the middle of a ſquare baſon, and becomes petrified at a ſmall diſtacne from the ſpring. The water is of a yellowiſh white, and the incruſtations have been uſed to build the houſes of Guancavelica. The workmen fill moulds with its water, and ſome days afterwards they find them incruſted with this ſtone. The ſtatuaries expoſe their moulds in this ſpring, and have only to give the poliſh in order to render their ſtatues tranſparent. All the ſtatues uſed in religious ceremonies, by the catholics of Lima, are of this ſubſtance, and are very beautiful.—Journal des Obſerv. tom. i. p. 434.

In the year 1760, Mr. Vegni deviſed a method of making a ſimilar uſe of the very white chalk which is contained in the waters of the baths

baths of St. Philip in Tuſcany. For this purpoſe the water is ſuffered to run for the ſpace of near a mile, in order that it may depoſit the ſulphur, the ſelenite, and the tufa which it contains; and in this purified ſtate it is uſed in the fabrication of bas reliefs. It is introduced at the roof of a building, into a cloſet conſtructed of planks fitted together. The water falls from twelve to fifteen feet in height, upon a wooden croſs placed on a poſt; by which fall it is divided, and daſhes laterally againſt ſulphur moulds, which are placed on the ſides of the cabinet. In this way it depoſits the particles of the earth which it contained, and the mould becomes filled. Mr. Vigni places the moulds upon pieces of wood which are moved circularly. This alabaſter is as hard as marble; and the incruſtation is more beautiful, and harder, in proportion as the poſition of the mould is more vertical, and its diſtance greater.

The Analyſis and Uſes of Calcareous Stone.

In 1755, Dr. Black proved that calcareous ſtone poſſeſſes, as one of its component parts, an air different from atmoſpheric air. He aſſerted that calcareous ſtone, when deprived of this air by calcination, forms lime; and that lime might again paſs to the ſtate of calcareous

ſtone by reſuming the principle it had been deprived of. In 1764, Macbride ſupported this doctrine by new facts. Jacquin added other experiments to theſe; and proved that lime and alkalis owe their cauſticity to the ſubtraction of this fixed air, at the ſame time that he pointed out ſeveral methods of depriving them of it.

The proceſſes which are moſt commonly uſed for the decompoſition of lime-ſtone, are fire and acids: the firſt is uſed in the making of lime; the ſecond in laboratories, when it is intended to procure the carbonic acid.

In order to form lime, the calcareous ſtone is calcined in furnaces, whoſe conſtruction is varied according to the nature of the combuſtibles made uſe of.

When pit-coal is uſed, an inverted cone is conſtructed of vitrifiable ſtone, which is filled by alternate ſtrata of coal and lime-ſtone; and the lime is taken out, after the operation, by an aperture at the top. In proportion as the maſs ſubſides, care is taken to ſupply the furnace at the top, in order that the flame and heat may not be loſt.

Bergmann has obſerved that moſt ſpecimens of calcareous ſtone which become black or brown by calcination, contain mangaueſe, and that the lime which they produce is excellent.

According to Rinmann, the white calcareous ſtones

ſtones which become black by calcination, contain about one tenth part of this ſubſtance.

Calcination deprives lime-ſtone of the acid and water which it contained. Theſe two principles are evidently replaced by the matter of heat itſelf. The odour of fire which quick-lime emits; the light which it affords when ſlacked in a dark place; the colour which it communicates to the lapis cauſticus; the property which it poſſeſſes of producing the oxide and the glaſſes of lead—all prove to us, as Mr. Darcet obſerves in the Journal de Phyſique for 1783, that in proportion as the calcareous ſtone is deprived of the aëriform principle, it combines with the igneous principle, which cannot be diſplaced but by the way of affinities. The beautiful experiments of Meyer, when diveſted of all theory, prove the ſame thing.

It is proved, from the experiments of Dr. Higgins, that the beſt lime is that which is made with the hardeſt and moſt compact ſtone broken into ſmall pieces, and heated ſlowly, until the furnace is become of a white heat. This heat muſt be kept up until the ſtone is no longer capable of effervefcing with acids. The lime becomes over-burned if the ignition be carried to a greater degree; and the produce is then a frit, which is no longer capable of being divided in

 water,

water, or of refuming with avidity the principles it had loft.

When pieces of calcareous ftone of different fizes are calcined, the lime will not all be of equal goodnefs; the fmall pieces confifting of over-burned lime, while the larger pieces are fcarcely altered in their central parts.

The beft lime is that which is the moft quickly divided by immerfion in water, and affords the greateft quantity of heat in this procefs, which caufes it to fall into the fineft powder. Good lime fhould likewife diffolve in the acetous acid without effervefcence, and leave the leaft poffible quantity of refidue.

Lime continually endeavours to refume the acid and the water of which the ftone was deprived by calcination: confequently, when it is left expofed to the air, it cracks, becomes heated, falls into powder with an increafe of bulk, and refumes the property of effervefcing. It is therefore of importance to ufe lime newly made, if the artift be defirous of poffeffing its whole force.

Lime is fparingly foluble in water, and this folution is called lime-water; the lime may be precipitated by means of carbonic acid, which regenerates calcareous ftone in the form of a precipitate.

Lime water is ufed to indicate the prefence, and determine the proportion, of carbonic acid in any mineral water.

Phyficians prefcribe it as an abforbent and detergent.

When lime-water is left in contact with the air of the atmofphere, a pellicle is formed at its furface, known by the name of cream of lime; this is the regenerated calcareous ftone.

The fuperb bafon of Lampi, one of the two principal refervoirs which furnifh the Royal Canal of Languedoc with water, was found to leak at the junction of the ftones. The fkilful engineer who directs thefe works, Mr. Pin, caufed lime to be flacked; which, paffing through thefe fmall apertures, became fupplied with carbonic acid, and formed a cruft, or very white covering, over its whole furface: fo that all the ftones of this fine piece of mafonry are connected together by this cement; and at prefent conftitute one fingle undivided fubftance, impenetrable to water.

The regeneration of calcareous ftone is very flowly effected by the proceffes hitherto defcribed. But this may be expedited by prefenting to the lime the principles with which it fo ftrongly tends to combine: this is accordingly done in works in the large way.

Lime is ufually flacked by pouring abundance of water upon it. A violent heat is thus excited; the lime falls down into powder, and a pafte is afforded by ftrongly working the lime together in proportion as it becomes faturated.

The count Razoumoufki has taken advantage of the heat which is difengaged when lime is flacked, to combine the lime with fulphur.

The degree of heat proper to effect this combination is 70 of Reaumur. At this point the fulphur, which is placed in contact with the lime, liquefies, becomes of a red colour, and forms a true fulphure or hepar of lime.

Mortar is made fimply by working fand, or other bodies infoluble in water, together with flacked lime.

We are acquainted with two kinds of fand at Montpellier; pit fand, and river fand: the former is almoft always altered by a mixture of vegetable and calcareous earth, which weaken its efficacy; the fecond is purer, and better fuited for the purpofe. Inftead of fand, the fragments or duft of ftone may be ufed: the angles which thefe fragments prefent, and the roughnefs of their furface, contribute to give a confiftence to the mortar.

The hardening of mortars appears to be owing merely to the progreffive regeneration of

lime-ſtone. They do not obtain the greateſt degree of hardneſs of which they are ſuſceptible, until they have reſumed all the carbonic acid of which the ſtone was deprived: and this operation is very ſlow, unleſs the combuſtion be facilitated by well-known methods, which conſiſt in mixing ſubſtances with the mortar which contain either the carbonic acid, or a principle analogous to it, ſuch as vinegar.

It is this regeneration of lime-ſtone, which is effected by the lapſe of time, that explains to us why the hardeſt ſtones afford the beſt lime; and why old mortars are found to poſſeſs a degree of hardneſs which modern artiſts have no hopes of attaining.

The remains of ancient buildings have induced certain philoſophers to conclude, that the ancients were in poſſeſſion of very valuable proceſſes for the making of mortar. Mr. De la Faye was of opinion, that thoſe enormous maſſes, in which the perfection of the mechanical proceſſes of the ancients only was admired, were made by coffer work; and he imagined that he had diſcovered, in Vitruvius, Pliny, and Saint Auguſtin, that their proceſs to extinguiſh lime differed from ours; and that the great difference which appears to exiſt between the ancient and modern mortars depends more parti-

particularly upon this circumſtance. Theſe interesting reſearches have induced him to propoſe that the lime ſhould be put into a baſket, and ſuffered to ſlack in the air ; as he thinks by this means it would preſerve a greater degree of force, and be leſs weakened than by the uſual proceſſes.

Loriot has attributed the ſuperiority of the mortars of the ancients to the means which they uſed to dry them ſpeedily; and in conſequence of theſe principles he mixes pounded bricks with flints, works the whole together with ſlacked lime, and dries the maſs with one-fourth part of quick-lime. Care muſt be taken to uſe only lime which is finely pulverized and ſifted ; for otherwiſe the mortar would crack, and be very imperfect.

Nature ſometimes preſents to us a ſuitable mixture of lime-ſtone and ſand, to form an excellent mortar, without any mixture of extraneous ſubſtances. Mr. De Morveau found this lime-ſtone in Burgundy ; Mr. de Puymaurin has deſcribed a ſpecies which he found in Berne ; and I have obſerved in Cevennes a natural mixture of this kind, in which the proportion of materials was ſo well aſſorted, that nothing more was neceſſary than to calcine it, and extinguiſh it in water, to form an excellent mortar.

SPECIES II.

Sulphate of Lime, Gypſum, Selenite, Plaſter Stone.

The Plaſter Stone loſes its tranſparency by calcination; at the ſame time that it becomes pulverulent, and acquires the property of again ſeizing the water of which it had been deprived, and reſuming its hardneſs: it does not give fire with the ſteel, nor efferveſce with acids.

We are more particularly indebted to Margraff for our acquaintance with the conſtituent principles of plaſter; and from ſubſequent experiments the following proportion of the ſame principles has been aſſigned. One hundred parts of gypſum contain thirty ſulphuric acid, thirty-two pure earth, thirty-eight water; it loſes nearly twenty per cent. by calcination.

We begin to be equally acquainted with the formation of this ſtone. The chevalier De Lamanon has aſſerted, that the numerous quarries of plaſter which are found in the vicinity of Paris, are the depoſition of an ancient fluviatile lake, formed by the Seine, Loiſe, and Marne, which flowed off on the ſide of Meulan. The wrought iron, and the various remains of animals which are found at the bottom of the quarries

quarries of Mont Martre, ſhew that its formation is not very ancient; and the indefatigable naturaliſt here cited conſiders the ſelenite as originally diſperſed in the water, precipitated in conſequence of its ſparing ſolubility, and heaped together in places determined by currents, waves, and other circumſtances.

Theſe facts, highly intereſting as they are in the natural hiſtory of plaſter, are inſufficient for the chemiſt who is deſirous of knowing likewiſe in what manner, and under what circumſtances, the combination of the ſulphuric acid and lime is made. I ſhall proceed to communicate ſome obſervations which our province affords.

1. I have obſerved in a black and pyritaceous clay of Saint Sauveur, extracted out of the work called Percement Dillon, many ſmall needle-formed cryſtals of ſelenite, from four to eight lines in length. At the ſurface of the ſoil where the ſame clay is more decompoſed, cryſtals of the ſame nature, but longer, thicker, and more numerous, are alſo found.

2. The marly and pyritous clay of Caunelle, near Moſſon, abounds with beautiful cryſtals of roſe-coloured plaſter, in the form of cocks-combs, obſerved by Mr. Dorthes.

3. The plaſter quarry of La Salle exhibits

 almoſt

almoſt alternately ſtrata of plaſter and ſtrata of black and pyritous clay, which effloreſces in the air.

4. Near the bridge of Herepian, on the declivity of Caſcaſtel, at Gabian, and in many other places, I have conſtantly found cryſtals of gypſum mixed and confounded with pyritaceous clays.

5. The ſulphureous depoſitions of ſolfatara often contain cryſtals of ſelenite.

From theſe facts it appears to me that the formation of gypſum may eaſily be conceived. It is not formed excepting in places where pyrites and clay more or leſs calcareous are found together; that is to ſay, its formation appears to be dependent on, and connected with, the preſence of ſulphur and lime.

Whenever, therefore, the pyrites is decompoſed, the ſulphuric acid which thence ariſes ſeizes the lime, and effloreſces in ſmall cryſtals, which are carried off by the water, and ſooner or later depoſited. I have obſerved perceptible depoſitions of plaſter on the banks of rivulets which waſh pyritous clays. I have likewiſe ſeen depoſitions of the ſame nature in rivers whoſe waters have been ſtrongly concentrated by the burning heat of our ſummer. And conſequently, if we ſuppoſe ſelenite to be diſperſed in more conſi-

derable

derable maſſes of water, there will be no difficulty in conceiving the formation of thoſe ſtrata which the plaſter quarries exhibit.

Meſſrs. De Cazozy and Macquart have obſerved the tranſition of the gypſum of Cracovia to the ſtate of calcedony. When the nucleus of calcedony is determined, it increaſes perceptibly in the courſe of time, even in cabinets; which proves that the quartzoſe juice, when once infiltrated into plaſter, combines with the lime, and determines this transformation.

Mr. Dorthes has proved that the quartz, in cocks-combs at Paſſy, owed its origin to plaſter; that this laſt ſubſtance having been carried away by ſolution, the quartzoſe juice has taken its place. Natural hiſtory exhibits ſeveral of theſe metamorphoſes.

Gypſum is found in the earth in four different ſtates.

1. In the pulverulent and friable form, which conſtitutes gypſeous earth, foſſil flour, &c.

2. In ſolid maſſes, which conſtitute plaſter-ſtone.

3. In ſtalactites, or ſecondary depoſitions. In this place we may arrange the ſtriated ſilky gypſums, the cauliflowers, the gypſeous alabaſters, and that prodigious variety of forms

which the ſtalactites aſſumes, whatever may be its component parts.

4. In determinate cryſtals, which uſually exhibit the following forms.

1. The compreſſed tetrahedral rhomboidal priſm.

2. The hexahedral priſm truncated at its ſummit.

3. The decahedral rhomboid. I apprehend that the lenticular gypſum may be referred to this laſt form, as it appears to me to be compoſed of ſeveral rhomboids united together ſideways. At all events I have, as the laſt reſult, obtained the rhomboidal form, by decompoſing this variety.

The colour of gypſum is ſubject to a great number of varieties, which are the ſigns of various qualities relative to its uſes. The white is the moſt beautiful, but ſometimes it is grey; and in this caſe is leſs eſteemed, and leſs valuable.

The ſeveral ſtates of the oxides of iron, with which it abounds in greater or leſs quantities, conſtitute its roſe-coloured, red, black, &c. varieties.

The ſpecific gravity of gypſum varies according to its purity.—See Meſſrs. Briſſon and

Kirwan;

Kirwan: the latter found it ſometimes of the weight of 2.32, and ſometimes 1.87.

It is ſoluble in about five hundred times its weight of water, at the temperature of 60 degrees of Fahrenheit.

When it is expoſed to heat, its water of cryſtallization is diſſipated, it becomes opake, loſes its conſiſtence, and falls into powder. If it be moiſtened, it becomes hard again, but does not reſume its tranſparency; a circumſtance which appears to prove that its firſt ſtate is a ſtate of cryſtallization.

If it be kept in a fire of conſiderable intenſity, in contact with powder of charcoal, the acid is decompoſed, and the reſidue is lime.

Its principles may likewiſe be ſeparated by finely pulverizing it, and boiling it with alkali.

It is fuſible by the blow-pipe, according to Bergmann; and in a porcelain furnace, according to Darcet.

The management of the fire in the calcination of gypſum is of great conſequence. Too much heat decompoſes it; and too little does not enable it to unite, and form a hard ſubſtance with water.

Calcined gypſum divides and diſperſes itſelf in water, with which it forms a paſte that may be caſt into every figure imaginable. We are indebted

indebted to this property for beautiful ornaments in the inſide of our houſes; but it cannot be uſed for external decorations, becauſe its ſolubility in water renders it gradually deſtructible by that liquid.

SPECIES III.

Fluate of Lime, Vitreous Spar, Fuſible or Phoſphoric Spar, Fluor Spar.

This ſtone is a combination of a peculiar acid, called the fluoric acid, with lime.

It decrepitates on heated coals, like the muriate of ſoda, or common ſalt. When ſlightly heated, it ſhines with a beautiful blue colour, that remains even under water, or in acids. The reſidue of this appearance of combuſtion is white and opake.

Its ſpecific gravity is, in general, from 3.14 to 3.18, according to Kirwan.

This ſpar enters into fuſion by a ſtrong heat, and corrodes the crucible: it likewiſe fuſes without effervefcence with the mineral alkali, the borate of ſoda, and the phoſphates of urine.

This ſtone poſſeſſes the moſt lively and various colours; and it is known under the names of falſe emerald, falſe amethyſt, or falſe topaz, accordingly as its colour is green, violet, or yellow.

The

The blue fluor ſpars commonly owe their colour to iron, but ſometimes to cobalt. Berlin Berchaft, tom. ii. p. 330.—Green fluors are coloured by iron, according to Rinmann. The moſt uſual form of fluate of lime is the cubic, with all the modifications which accompany this primitive form.

When this ſtone is diſtilled with its own weight of ſulphuric acid, the firſt product conſiſts of elaſtic whitiſh vapours, which fill the receiver, and depoſit a cruſt at the ſurface of the water, while the water itſelf becomes acidulous. The reſidue in the retort is ſulphate of lime, according to Scheele. The cruſt which is formed on the water of the receiver is ſiliceous earth; and the water itſelf being ſaturated with the vapour, conſtitutes the fluoric acid.

The moſt aſtoniſhing property of this acid is doubtleſs that of ſeizing the ſiliceous earth, which is a conſtituent principle of the glaſs, and volatilizing it with itſelf.

In order to have the acid in a ſtate of greater purity, and exempt from every mixture of ſilex, the operations are performed in retorts of lead; but Mr. De Puymaurin is convinced, as well as myſelf, that the acid even then is ſeldom pure, becauſe the moſt beautiful fluor contains

almoſt

almoſt always a ſmall quantity of ſilex, which the acid carries with it. The whiteſt, the moſt tranſparent, and the moſt regularly-cryſtallized fluor, diſtilled on the water bath in a leaden retort, afforded me an acid contaminated by a ſmall quantity of ſilex.

Mr. Meyer having uſed every poſſible means to obtain this acid in a ſtate of great purity, is convinced that, when the acid does not find ſilex in the retort, it attacks the ſides of the receiver, and becomes changed.

This acid may be preſerved in bottles whoſe internal ſurfaces are coated with wax diſſolved in oil.

The fluoric acid has ſome analogy with the muriatic; and ſome chemiſts have even confounded them together: but they differ eſſentially from each other.

The fluoric acid—1. When combined with pot-aſh, preſents a gelatinous ſubſtance, which when dry retains one-fifth of the alkali employed, and forms a true neutral ſalt. 2. It acts nearly in the ſame manner with ſoda. 3. With ammoniac it affords a jelly, which when dry exhibits all the appearances of ſilex. 4. When mixed with lime-water, it regenerates the fluate of lime. 5. It does not attack gold, nor diſſolve ſilver; and

and combines in preference with oxides, ſuch as thoſe of lead, iron, copper, tin, cobalt, and even of ſilver.

One part of the fluate of lime, fuſed with four parts of cauſtic fixed alkali, forms a ſalt inſoluble in water. The ſame quantity of fluate of lime, treated in the ſame manner with the carbonate of pot-aſh, or mild vegetable alkali, affords a ſoluble ſalt; and at the bottom of the water a calcareous earth is found, which proves that the fluoric acid is not ſeparated but by double affinity.

This ſtone, which hitherto has not been employed but as a flux, or in the fabrication of ornaments, appears to me to deſerve the moſt particular attention. Its texture ſeems to be lamellated like the diamond; and like that ſtone it is not capable of double refraction, as the abbé Rochon has obſerved. Its phoſphoreſcence has likewiſe ſome relation with the combuſtibility of the diamond, and it has lively and varied colours. All theſe circumſtances eſtabliſh an analogy between theſe two ſubſtances; and might lead us to ſuſpect that the conſtituent principles of the diamond exiſt in this ſtone, mixed and combined with an acid and lime, &c.

The fluoric acid poſſeſſes the very ſingular property of attacking glaſs, and diſſolving and

carrying

carrying off its ſiliceous part. Margraff firſt obſerved this property; but Meſſrs. De Puymaurin and Klaproth have very happily applied it to the art of engraving on glaſs.

This acid is employed to corrode the glaſs, in the ſame manner as aqua-fortis is uſed to engrave upon copper.

Some authors, particularly Mr. Monnet, have endeavoured to prove that this acid was nothing elſe but a modification of the acid uſed in the decompoſition of the ſpar. They ſeem to found their opinion chiefly on the circumſtance, that the acid obtained exceeds in weight the ſpar made uſe of; but they have neglected the increaſe of weight which muſt ariſe from the eroſion, diſſolution, and mixture of the glaſs of the diſtilling veſſels. And indeed theſe experiments do not appear to me to invalidate in the leaſt the eternal truths which have iſſued from the laboratory of the celebrated Scheele; otherwiſe ſuch modifications in the acids employed, would in my opinion afford a phenomenon ſtill more aſtoniſhing than the exiſtence of this peculiar acid.

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SPECIES IV.

Nitrate of Lime, Calcareous Nitre.

This ſalt, as well as thoſe which remain to be treated of in the preſent genus, exiſts only in waters. Their great ſolubility, and their ſpontaneous deliqueſcence, do not permit them to form durable maſſes, or to exiſt in the form of ſtones.

The nitrate of lime is principally formed near inhabited places: old plaſter affords it in abundance by lixiviation. It is one of the ſalts which abound in the mother waters of the ſaltpetre makers; and it has been found in ſome mineral waters.

It is uſually obtained in the form of ſmall needles, applied ſideways to each other.

When a ſolution of nitrate of lime is concentrated to a gelatinous conſiſtence nearly equal to that of ſyrup, it forms, in proceſs of time, cryſtals in hexahedral priſms.

Two parts of cold water diſſolve one of this ſalt; and boiling water diſſolves more than its own weight.

Its taſte is bitter and diſagreeable.

It liquefies eaſily on the fire, and becomes ſolid by cooling: if it be ſtrongly calcined, and

carried into the dark, it is luminous, and conſtitutes Baldwin's phoſphorus.

It loſes its acid in a violent and continued heat. When diſtilled in cloſe veſſels, it affords the ſame products as nitre by the decompoſition of its acid.

Projected upon ignited coals, it detonates in proportion as it becomes dry.—See De Fourcroy.

Its acid may be diſengaged by means of clay and of the ſulphuric acid.

The alkalis and barytes precipitate its earth.

The ſulphuric ſalts, and the carbonates of alkali, decompoſe it by double affinity.

SPECIES V.

Muriate of Lime, Calcareous Marine Salt.

This combination exiſts more eſpecially in the waters of the ſea; and contributes to give to theſe waters that bitter taſte which has improperly been referred to bitumens that have no exiſtence.

This ſalt is very deliqueſcent; one part and a half of water diſſolves one of this ſalt; and hot water diſſolves more than its own weight.

It may be made to cryſtallize by concentrat-

 ing

ing its ſolution to the 45th degree of Baumé, and expoſing it afterwards in a cool place.

With theſe precautions it affords a ſalt in tetrahedral priſms terminated by four-ſided pyramids.—See De Fourcroy.

It enters into fuſion with a moderate heat; but is decompoſed with great difficulty. It acquires by calcination the property of ſhining in the dark, and is called the phoſphorus of Homberg.

It is decompoſed by barytes and the alkalis. The concentrated ſulphuric acid, poured upon a very ſtrong ſolution of muriate of lime, diſengages the acid in vapours, and forms a ſolid precipitate; an appearance which ſeems in an inſtant to transform two liquids into a ſolid, and produces a very ſtriking effect. The theory of this phenomenon is eaſily deduced from the very great ſolubility of the muriate, and the almoſt abſolute inſolubility of the ſulphate which takes its place.

SPECIES VI.

Phoſphate of Lime, Calcareous Phoſphoric Salt.

This phoſphate of lime has been found in Spain, in the kingdom of Eſtramadura, by Mr. Bowle.

It is a whitiſh ſtone of conſiderable denſity,

not hard enough to give fire with the ſteel. It is found in horizontal ſtrata, repoſing upon quartz, and exhibiting vertical, flattened, and cloſe fibres. When thrown on ignited coals, it does not decrepitate, but burns quietly, and affords a beautiful green light, which ſeems to penetrate through it, and does not diſappear ſo quickly but that a ſufficient time is admitted to contemplate its brilliancy with admiration. Before the blow-pipe it runs into a white enamel, without boiling up; whereas bones ſupport the moſt violent heat without fuſion. Its habitudes with the nitric and ſulphuric acids are the ſame as thoſe of calcined bones; its acid may be ſeparated and brought into the ſtate of an animal glaſs; it may be decompoſed, and the phoſphorus extracted.

Mr. Prouſt, from whom we borrow theſe intereſting details, obſerves likewiſe that this ſtone is found to compoſe the maſs of entire hills in the neighbourhood of the village of Logroſan, in the juriſdiction of Truxillo, a province of Eſtramadura. The houſes and the walls of incloſures are built of it.

GENUS II.

Earthy Salts with Baſe of Barytes.

The moſt common ſtate in which Barytes is found

found is in combination with the ſulphuric acid.

SPECIES I.

Sulphate of Barytes, Ponderous Spar.

This ſtone is the moſt ponderous we are acquainted with. Its ſpecific gravity is commonly from 4 to 4.6.

It decrepitates in the fire, melts before the blow-pipe without addition, and fluxes diſſolve it with effervefcence.—See the notes of the abbé Mongez*.

Mr. Darcet ſucceeded in fuſing it in a porcelain furnace.

It has been often confounded with gypſum and fluor ſpar; but the characters of theſe two ſubſtances are very different.

It almoſt always accompanies metallic ores, and it is even conſidered as an happy preſage of finding them. Becher has affirmed that it was a certain indication *vel preſentis vel futuri metalli*: and I think that there is reaſon to conſider it as the vitrifiable ſtone of this celebrated naturaliſt. The proofs of my aſſertion may be ſeen in the preliminary ideas of my treatiſe

* Manuel du Mineralogiſte.

on metallic ſubſtances (in this work). The analogy between this ſtone and metals has been eſtabliſhed by the experiments of Bergmann and of Mr. Lavoiſier.

This ſtone, when rather ſtrongly heated, exhibits a blueiſh light in the dark. To form theſe kinds of phoſphori, the ſpar is pulverized, the powder is kneaded up with mucilage of gum tragacanth, and the paſte is formed into pieces as thin as the blade of a knife. Theſe pieces are afterwards dried, and ſtrongly calcined by placing them in the midſt of the coals of a furnace; they are afterwards cleared by blowing on them with the bellows. In this ſtate, if they be expoſed to the light for a few minutes, and afterwards carried into a dark place, they ſhine like glowing coals. Theſe pieces ſhine even under water; but they gradually become deprived of this property, which however may be reſtored again by a ſecond heating.—See De Fourcroy.

Ponderous ſpar is eaſily divided into plates by the ſlighteſt blow; and the moſt uſual form which it affects is that of an hexahedral priſm, very flat, and terminated by a dihedral ſummit.

Ponderous ſpar has been found at the diſtance of one league from Clermont d'Auvergne, in the form of hexahedral priſms terminated

by

by a tetrahedral or dihedral pyramid. I have ſeen cryſtals of two inches in diameter.

It frequently happens that the form of theſe cryſtals is not very determinate; but all the ſtones of the nature of theſe exhibit a confuſed aſſemblage of ſeveral plates applied one upon another, and capable of being ſeparated by a very ſlight blow. Ponderous ſpar is inſoluble in water; and upon this property is founded the virtue poſſeſſed by the muriate of barytes, to manifeſt the ſligheſt portions of ſulphuric acid in any combination which contains it.

Barytes adheres more ſtrongly to acids than the alkalis themſelves do; and when the carbonates of alkalis precipitate it, the effect takes place in the way of double affinity.

SPECIES II.

Carbonate of Barytes.

This combination has the ſpecific gravity of 3·773·

One hundred parts contain twenty-eight water, ſeven acid, ſixty-five pure earth.

The ſulphuric, nitric, and other acids attack it with effervefcence.

Although the carbonic acid poſſeſſes the ſtrongeſt affinity with this earth, it is very ſel-

dom found in combination with it: and I am acquainted with its exiftence only on the authority of Mr. Kirwan, who affirms that Dr. Withering prefented him with a fpecimen from Alfton Moor, in Cumberland; which refembles alum, with the difference that its texture is ftriated, and its fpecific gravity is 4.331*.

Mr. Sage analyfed this ftone, which was prefented to him by Mr. Greville.—See the Journal de Phyfique for April 1788.

SPECIES III.

Nitrate of Barytes.

The nitric acid diffolves pure barytes, and forms a falt which cryftallizes fometimes in large hexagonal cryftals, and frequently in fmall irregular cryftals.

This nitrate is decompofed by fire, and affords oxigene.

The pure alkalis do not difengage the barytes, but the alkaline carbonates precipitate it by double affinity.

The fulphuric and fluoric acids feize this earth from the nitric acid.

It has not yet been found native.

* It is plentifully found in England, in the lead mine of Anglezark, near Chorley in Lancafhire. See the Manchefter Memoirs, vol. iii. p. 598. T.

SPECIES IV.

Muriate of Barytes.

This ſalt is capable of aſſuming a form conſiderably reſembling that of ſpar in tables or plates. It exhibits, with the earths, acids, and alkali, phenomena nearly ſimilar to thoſe of the nitrate of barytes.

It forms one of the moſt intereſting re-agents to aſcertain the exiſtence of the ſmalleſt particle of ſulphuric ſalt in any water; becauſe, by the ſudden exchange of principles, the reſult is ponderous ſpar, which immediately falls down.

It has not yet been found in a native ſtate.

GENUS III.

Earthy Salts with Baſis of Magneſia.

Theſe ſalts were not well known before the time in which the celebrated Black proved that they ought not to be confounded with calcareous ſalts. They may be diſtinguiſhed from theſe by the bitter taſte which almoſt all of them poſſeſs.

They are in general very ſoluble in water. Lime-water precipitates them, as does likewiſe ammoniac, or the volatile alkali.

SPECIES I.

Sulphate of Magnesia, Epsom Salt.

This salt is frequently met with; it exists in several mineral waters, such as those of Epsom, of Sedliz, &c. It was at first distinguished by the name of the springs which produced it; and it is still known by the name of the bitter cathartic salt, on accout of its taste and virtues.

The sulphate of magnesia, in commerce, comes either from the salt springs of Lorraine, from which this salt is extracted with a mixture of sulphur; or otherwise from the salt works in the environs of Narbonne, where it is extracted from the mother waters which contain it abundantly.

The sulphate of magnesia, in commerce, has the form of small silky needles, very white. It does not effloresce in the air, which distinguishes it from the sulphate of soda.

The crystals of the pure sulphate of magnesia are quadrangular prisms, terminated by pyramids of an equal number of sides.

The sulphate of magnesia prepared in our salt works is sold at from thirty to forty livres the quintal; it contains in the pound three sixteenths of sulphate of soda, two sixteenths muriate of magnesia, one sixteenth muriate of soda, six

six sixteenths true sulphate of magnesia: the rest consists of salts with basis of lime.

The sulphate of magnesia, when exposed to the fire, liquefies, and loses half its weight. The remainder is dry, and requires a strong fire to fuse it.

Water dissolves its own weight of this salt, at the temperature of 60 degrees of Fahrenheit's thermometer.

One hundred parts of this salt contain twenty-four parts acid, nineteen earth, and fifty-seven water.

It exists in all the waters in the environs of Montpellier.

Sometimes it is found efflorescent upon schisti, from which it may be collected. I have found it upon a mountain in Rouergue, in a quantity sufficiently great to be collected to advantage: birds of passage devour it greedily. This salt is used in preference to others as a purgative.

SPECIES II.

Nitrate of Magnesia.

The celebrated Bergmann, who has combined magnesia with the various acids, observes that the nitric acid forms with it a salt capable of afford-

affording, by proper evaporation, prismatic, quadrangular, truncated crystals. The same chemist adds, that this salt is deliquescent. Mr. Dijonval affirms that he obtained crystals that were not deliquescent; and accident has afforded me a salt of this kind in mother water of nitre concentrated to the 45th degree of the areometer. Its form was that of prisms with four sides, very much flattened, very thick, and very short.

This salt decomposes the muriates; alkalis precipitate its magnesia, as does likewise lime.

SPECIES III.

Muriate of Magnesia.

The muriate of magnesia exists in the mother water of our salt works; its taste is very bitter.

According to Bergmann, it forms a salt in small needles, so deliquescent that it cannot be obtained but by strongly concentrating the solution, and afterwards exposing it to intense cold.

Lime-water, barytes, and the alkalis precipitate the magnesia; it may likewise be separated by means of fire.

SPECIES IV.

Carbonate of Magnesia.

Though magnesia has the greatest affinity with the carbonic acid, I do not think that nature has ever exhibited this combination. It is obtained by precipitating the magnesia from Epsom salt, by means of the carbonates of alkali; and in this state it is called effervescent magnesia, or magnesia not calcined.

The carbonate of magnesia contains in the quintal thirty parts acid, forty-eight earth, and twenty-two water.—See Kirwan and Bergmann.

Magnesia sticks to the tongue; and assumes, in drying, a certain transparency, which it preserves until it has lost all its water, which is not easily driven off.

Fire carries off the water and the acid; and in this state the residue is called calcined magnesia.

The carbonate of magnesia is soluble in water in the proportion of several grains in an ounce of the fluid.

But we are indebted to Mr. Butini for a very singular observation—that cold dissolves more than hot water, and that the magnesia may be precipitated by heating the water which holds it in solution. Hence it arises that waters loaded

loaded with magnefia become white and turbid by ebullition.

The celebrated Bergmann had advanced that the carbonate of magnefia is cryftallizable. Mr. Butini, by concentrating a faturated folution of this falt with a gentle heat, obtained groups of cryftals, which, when examined by the microfcope, appeared to be hexagonal truncated prifms. I have obtained fimilar fnow-like flocks by precipitating magnefia by the addition of an alkali, drop by drop.

The carbonate of magnefia is ufed in medicine as a purgative. The calcined magnefia ought to be preferred as an abforbent.

GENUS IV.

Earthy Salts with Bafe of Alumine.

The fubftance which in the arts is known by the name of Clay, is a natural mixture of feveral earths.

Alumine, or pure clay, is capable of combining with the greateft part of the known acids; but the moft common of thefe falts is alum.

SPECIES I.

Sulphate of Alumine, Alum.

Though alum be very commonly met with, yet the combination of principles which constitute it is not effected without considerable difficulty.

Pure clay upon which the fulphuric acid is digefted, is diffolved with difficulty; and it is by no means eafy to bring this combination to regular cryftals. The ufual product is a falt, which appears to be formed by fcales applied one upon the other.

The moft ordinary procefs to diffolve alumine by means of an acid, confifts in calcining the clay, impregnating it with the acid, and facilitating its action by an heat of 50 or 60 degrees of Reaumur. But a fimpler method, which I have ufed in my manufactory of alum, confifts in prefenting the acid in vapours, and under the dry form, to the clay properly prepared. For this purpofe I calcine my clays, and reduce them into fmall pieces, which I fpread over the floor of my leaden chambers. The fulphuric acid, which is formed by the combuftion of a mixture of fulphur and faltpetre, expands itfelf in the cavity of thefe chambers, and

and exifts for a certain time in the vaporous form. In this form it has a ftronger action than when it has been weakened by the mixture of a quantity of water more or lefs confiderable: fo that it feizes the earths, combines with them, caufes them to increafe in bulk by the efflorefcence which takes place, and at the end of feveral days the whole furface expofed to the vapour is converted into alum. Care is taken to ftir thefe earths from time to time, that they may fucceffively prefent all their furfaces to the action of the acid.

But whatever procefs may be ufed to combine the acid with clay, it is neceffary to expofe the aluminized earths to the air during a greater or lefs fpace of time, in order that the combination may be more accurate, and the faturation more complete.

Moft of the alum in commerce is afforded by ores which are dug out of the earth for this purpofe. We may reduce all the operations of this manufacture to three or four: the decompofition of the ore, the lixiviation of the ore, the evaporation of thefe lixiviums, and the cryftallization of the alum.

1. The decompofition of the mineral is effected either in the open air without affiftance, or elfe by means of fire.

When

When the mineral is left to decompose spontaneously, nothing more is done than to dispose the stone which contains the principles of alum in strata or layers. The pyrites becomes heated; acid is formed, which dissolves the clay; and the salt arising from this combination exhibits itself by the efflorescence of the ore. The decomposition may be accelerated by watering the heap of pyrites; but the operation may be still more abridged by the assistance of fire.—The method of applying the heat varies prodigiously. On this head Bergmann may be consulted; but in general it may be observed that it ought not to be either too strong or too weak. In the first case it volatilizes the sulphur, and in the second it retards the operation.

The ore of alum is sometimes impregnated with a sufficient quantity of bitumen to maintain the combustion.—See my Memoir on the Alum Ore of Vabrais, 1785.

2. When the ore has effloresced into alum, the salt is extracted by lixiviation. For this purpose the same water is passed over several heaps of aluminous earth, in order to saturate it. The water which is first passed over the earth dissolves in preference the vitriol, which is more or less abundant; and this salt may be

 separated

ſeparated from the alum by a previous cold waſhing.

3. This lixivium, or ſaline ſolution, is carried into leaden caldrons, where the fluid is properly concentrated. In this part of the proceſs it is that an accurate ſaturation of the alum is effected when the acid is in exceſs; and for this purpoſe alkalis are added, which ſerve likewiſe ſingularly to facilitate the cryſtallization. The celebrated Bergmann has propoſed to boil clay with the ſolution, to ſaturate the exceſs of acid. This proceſs ſeems in every point of view to be advantageous; but it appears to me to be impracticable, becauſe the ſuperabundant acid cannot be made to combine with the clay but by a very long ebullition; and I have obſerved that, by afterwards evaporating the fluid to cauſe it to cryſtallize, this clay falls down, and oppoſes the cryſtallization. I have varied the proceſs in a variety of ways, without obtaining the ſucceſs which its celebrated author predicted.

There are methods of greater or leſs accuracy to judge of the degree of concentration to which it is proper to carry the lixivium, in order to obtain a good cryſtallization: ſuch are, the immerſion of an egg in the liquid, the effuſion of ſome drops of the lixivium on a plate, &c. Mr. De Morveau has propoſed a metallic hygrometer;

grometer; but this inftrument cannot be confidered as very accurate, becaufe its immerfion in the liquid is proportional to the heat of the fluid in which it is plunged.

4. The lixivium is then conveyed into coolers, where it cryftallizes by mere refrigeration. The pyramids of alum are conftantly turned towards the bottom of the veffel, more efpecially thofe which fix themfelves to the fticks which are put into the liquor to multiply the furfaces.

Alum affects the form of two tetrahedral pyramids, applied to each other bafe to bafe. Sometimes the angles are truncated, and thefe truncatures take place moft frequently when the lixivium is flightly too acid.

This falt requires fifteen times its weight of water to diffolve it, at the temperature of 60 degrees of Fahrenheit, according to Kirwan.

Its tafte is ftyptic: it lofes its water of cryftallization by heat; at the fame time that it fwells up, and is converted into a light and white fubftance, called burned or calcined alum.

If it be urged by a violent degree of heat, it lofes part of its acid, and becomes taftelefs. The refidue is no longer fufceptible of cryftallization, and precipitates in the form of a very fine adhefive powder, in proportion as the water is difperfed by evaporation.

 Alumine

Alumine is precipitated from this ſolution by magneſia, barytes, and the alkalis: theſe laſt diſſolve the precipitate in proportion as it is formed, if they be added in exceſs.

Alum is a very valuable material in the arts. It is the ſoul of the art of dying, and ſerves as the mordant to all colours. It is uſed to prepare leather, to impregnate paper and cloths intended to be printed. It is added to tallow, to render it harder; it enters into the preparation of a glue for the deſtruction of vermin; it is employed in England, and elſewhere, to give whiteneſs, and additional weight, to bread. When fuſed with ſaltpetre of the firſt boiling, it forms a very white cryſtal mineral.

The printers rub their balls with calcined alum, to cauſe them to take the ink. Surgeons employ it to corrode fungous or proud fleſh.

SPECIES II.

Carbonate of Alumine.

The argillaceous earth precipitated from the ſolution of alum by the carbonates of alkalis, combines with their acid; but this ſalt is very rarely found in nature. I know only of the obſervation of Schreber which aſcertains its exiſtence. This naturaliſt aſſerted that the earth known by the

the name of Lac Lunæ is a true carbonate of alumine.

Although alumine be ſoluble in the other acids, we are very little acquainted with its combinations. It is only known that the nitric acid diſſolves it, that the ſolution is aſtringent, and that it may be obtained in ſmall ſtyptic and deliqueſcent cryſtals.

The muriatic acid has a more evident action upon alumine. This muriate is gelatinous and deliqueſcent.

Theſe ſalts have not been applied to any uſe, and they are no where found in nature.

GENUS V.

Earthy Salts with Baſe of Silex.

Silex is of all the known earths that which combines the moſt difficultly with acids.

We are even acquainted with no other acid than the fluoric which exerts an evident action upon it. It riſes with it, and holds it in ſolution until it abandons it to unite with water.

Some experiments of Mr. Achard gave reaſon to think that the carbonic acid diſſolved ſilex; but the Pariſian chemiſts did not obtain the reſults announced by the chemiſt of Berlin. Mr. De Morveau ſeems to have proved that

iron and the carbonic acid were neceffary to form rock cryftals: but this acid does not remain united and combined with the earth; fo that we have not hitherto arrived at any proof of its diffolving virtue.

CLASS II.

Concerning the Combination and Mixture of Primitive Earths, or Earthy Mixtures.

The pure and fimple earths, fuch as we have defcribed them, are rarely found on the furface of the globe. They are conftantly mixed with each other, and form maffes of greater or lefs magnitude, and various hardnefs, according to the nature of the earths, their ftate of divifion, and the character of the foreign fubftances which are combined with them, fuch as iron, bitumens, &c.

It may be eafily underftood that the number of compofitions which can refult from the mixture of five primitive earths, would be infinite, if we were to pay attention to fuch flight varieties as depend on the proportions of the mixture: but I fhall not confider any mixtures as conftituting fpecies truly diftinct, except fuch as differ in the identity of their conftituent principles. The flight differences in the proportions of thefe prin-

principles may indeed occafion modifications in the form, the hardnefs, the colour, &c. But thefe can never conftitute more than varieties.

We fhall naturally deduce the genus from the ftone or earth which predominates in any mixture, and appears to communicate its own character to the total mafs. In this manner we fhall clafs among the calcareous mixtures fuch ftones as exhibit to our obfervation the properties of lime-ftone to fuch a degree, that they would be taken to be purely calcareous if the chemical analyfis did not prove the exiftence of other principles.

The genus ought not in ftrictnefs to be taken and deduced from the earthy principle which predominates; for the character of the whole mafs, or of the mixture, is very frequently given by an earth which does not form the moft abundant principle; as we obferve more efpecially in magnefian earths, where the filex predominates over the magnefia.

GENUS I.

Calcareous Mixtures.

According to the principles we have laid down, we muft refer to this place thofe ftony mixtures in which the properties of lime-ftone predominate.

SPECIES I.

Lime-ſtone and Magneſia.

This mixture is very common; almoſt all the calcareous ſtones contain magneſia. Mr. Bayen has deſcribed a variety in the Journal de Phyſique, t. xiii. which contain in the hundred parts ſeventy-five carbonate of lime, twelve magneſia, and thirteen iron: it is the earth of Crentzwald. Mr. Woulfe has deſcribed another variety in the Philoſophical Tranſactions for 1779. It afforded ſixty parts carbonate of lime, thirty-five carbonate of magneſia, and three of iron.

The analyſes which I have made of ſeveral lime-ſtones in our province, conſtantly afforded magneſia.

SPECIES II.

Lime-ſtone and Barytes.

Mr. Kirwan has informed us that this ſpecies is found in Derbyſhire, in the form of a ſtone, and likwiſe in the earthy ſtate. It is of a grey colour, and harder than ordinary lime-ſtones.

SPECIES III.

Carbonate of Lime and Alumine.

This mixture is frequently met with. It is commonly known by the name of Marle. The proportions of the two conſtituent principles are infinitely various. It is upon this proportion that the diſtinction of fat marles and lean marles depends, and diſpoſes them to ſerve as manure for earths of different kinds. The marles are almoſt always coloured by iron.

They appear to ariſe from the decompoſition of the natural mixtures of chalk and clay, and contain more or leſs of ſilex; but the analyſis which I made ſix years ago of all the marles I could procure, convinced me that they were often nothing more than a mixture of clay and chalk. I have likewiſe found magneſia in marles, ſometimes in the quantity of ſeventeen parts in the hundred; but, in general, they may be conſidered as formed eſſentially by the two earths here mentioned.

Alumine is found likewiſe mixed with carbonate of lime in marbles. Mr. Bayen has proved this in the ſecond volume of the Journal de Phyſique: and I have confirmed the truth of his reſults by the analyſis of ſeveral marbles of our province. It is even upon this principle that

we may account for the greaſy poliſh which ſome of them take.

The very evident difference which may be eſtabliſhed between the mixtures which form marle and marble, is, that the firſt is the immediate product of a decompoſition principally effected by the alterations of the iron which it contains; whereas the ſecond is produced by a purely mechanical mixture of two principles already formed, which being pounded, and ground as it were together, form a compact, hard, cloſe aſſemblage, ſuſceptible of the moſt beautiful poliſh.

SPECIES IV.

Lime-ſtone and Silex.

This ſpecies is not common. It is known under the name of Stellated Spar, Stern Schoerl of the Germans. It is opake, and of a radiated texture or form. Mr. Fichtel found it in lime-ſtone on the Carpathian mountains. It efferveſces with acids; and, according to Mr. Bindheim, one hundred parts of this ſtone contain ſixty-ſix carbonate of lime, thirty ſilex, and three iron.—See Kirwan.

The mixture of the pulverulent remains of the primitive rocks tranſported into our country

by

by the rivers which riſe in the Alps and the Cevennes, together with our own calcareous fragments, frequently form beds of a ſtone of this nature. The only difference between them is, that our mixtures exhibit a confuſed aſſemblage of all the principles which belong to the primitive rocks, ſuch as clay, ſilex, and others.

SPECIES V.

Limeſtone and Bitumen.

This mixture is known by the name of Swineſtone. It abounds in the dioceſes of Alais and Uzes: I have ſeen the calcareous rock impregnated with bitumen in an extent of more than three leagues diameter. It is even ſo abundant in ſome parts, that it diſtils through the clefts of the rocks, and forms ſtalactitous bitumen, which the peaſants collect to mark their ſheep, or to greaſe their cart-wheels. The heat of our ſummer ſometimes ſoftens it to ſuch a degree, that it flows into the roads, where it adheres to and impedes the motion of the ſledges and other carriages.

In ſome places the ſtone is ſo well impregnated with bitumen, that it may be wrought; but the blow of a hammer cauſes it to emit an abominable ſmell. Mr. D'Avejan, biſhop of Alais,

Alais, having uſed this ſtone to pave the apartments of his palace, the friction and heat diſengaged ſo unpleaſant a ſmell, that his ſucceſſors were obliged to ſubſtitute a ſtone of another kind in its ſtead.

Mr. De la Peyrouſe found this ſtone in large maſſes near Saint Beal in Comminge, at L'Eſtagneau, and at the mill of Langlade.

SPECIES VI.

Lime-ſtone and Iron.

Iron is almoſt always a conſtituent part of lime-ſtone; but it ſometimes exiſts in ſuch a proportion, that theſe mixtures conſtitute iron ores. Mr. Kirwan deſcribes two of this nature; one of which contains twenty-five pounds of iron in the quintal, and the other ten. Mr. Rinmann has deſcribed ſtalactites which afford iron, in the proportion of from twenty-ſeven to twenty pounds in the quintal.

Calcareous iron ores are wrought in many parts of our province. I have myſelf obtained forty-four pounds of iron in the quintal, from a calcareous ſtone which abounds on the mountain of Frontignan.

It is common to find, in our calcareous mountains, hematites rich in iron, whoſe baſe is calcareous;

careous; we find likewiſe ſpecies of ludus of the ſame genus, and ſometimes even tufa, whoſe formation ariſes from waters loaded with iron and lime.

The ſpathoſe iron ores are of the ſame claſs as thoſe we have juſt treated of.

GENUS II.

Barytic Mixtures.

Theſe, mixtures are very rare, becauſe the ſtone itſelf is ſcarce. We ſhall mention only two ſpecies.

SPECIES I.

Sulphate of Barytes, Petroleum, Gypſum, Alum, and Silex.—Bergmanni Sciagr. ſ. 90; Kirwan Min. p. 60.

The name of Hepatic Stone (Lapis Hepaticus) has been given to this mixture.

The colour varies much: its texture is uniform, lamellated, ſcaly, or ſparry. It takes the poliſh of alabaſter.

It forms a kind of plaſter by calcination, and emits a ſtrong and fetid ſmell by friction.

One hundred parts of this ſtone contain thirty-three barytes, thirty-eight ſilex, ſeventeen alum, ſeven gypſum, and five petroleum.

SPECIES II.

Carbonate of Barytes, Iron and Silex.

Mr. Kirwan has mentioned this ſtone on the authority of Mr. Bindheim. It is inſoluble in acids, and of a ſparry texture ; but he is tempted to conſider it as a ſulphate of barytes, in conſequence of the property obſerved by Mr. Bindheim, that it becomes ſoluble in acids, after having been calcined with oil.

GENUS III.

Magneſian Mixtures.

All the ſpecies compriſed in this genus poſſeſs characters ſufficiently ſtriking, and eaſily known. They are in general greaſy and ſoft to the touch ; they may be cut with a knife, turned in a lathe, and converted into any form at pleaſure. They take a tolerably good poliſh. Some of them are diſpoſed into fibres ; and theſe fibres poſſeſs, for the moſt part, a remarkable degree of flexibility. They ſtick to the tongue like clays ; but do not, like them, ſoften in the water.

SPECIES I.

Pure Magnefia, Silex, and Alumine.

SPECIES II.

Carbonate of Magnefia, Silex, and Alumine.

The mixture of thefe three earthy principles forms talcs, fteatites, pot-ftones, or lapides ollares.

The difference which analyfis fhews between thefe two fpecies, is almoft entirely confined to the proportions of their conftituent principles. This circumftance might appear fufficient to authorife us in confidering them only as varieties of each other. But as the magnefia is pure in the talc, and in the ftate of carbonate in the fteatites, we fhall confider them as different fpecies.

1. Pure magnefia, mixed with near twice its weight of filex, and lefs than its weight of alumine, forms talc. It is of a white, grey, yellow, or greenifh colour; foft and foapy to the touch, compofed of tranfparent laminæ placed upon each other. Thefe laminæ are more tender than thofe of mica; they lock together, and are ufually divided into rhombi, and may be crufhed or fcratched with the nail.

Its

Its ſpecific gravity is 2.729.

Fire renders it more brittle and white; but it is infuſible by the blow-pipe, and can ſcarcely be fuſed by the addition of alkali. The borate of ſoda, and the phoſphate of urine, fuſe it with a ſlight efferveſcence.

Muſcovy talc is compoſed of large elaſtic, flexible, and tranſparent leaves. Plates of talc have been raiſed in the quarries of Vitim in Siberia which were eight feet ſquare.

2. Steatites is uſually of a greeniſh white: it may be eaſily cut with a knife; and the duſt which is produced by ſcraping it does not readily mix with water.

Its ſpecific gravity is about 2.433.

It is infuſible alone, hardens in the fire, and becomes white. The borate of ſoda facilitates its fuſion; but ſoda, and the phoſphates of urine, do not perfectly diſſolve it.

According to the analyſis of Bergmann, one hundred parts of ſteatites contain eighty ſilex, ſeventeen magneſia in the ſtate of carbonate, two alumine, and one iron.

Steatites is ſometimes found in maſſes of indeterminate figure, and ſometimes cryſtallized, ſuch as that which Mr. Gerhard found at Raichewtein in Sileſia. Chem. Ann. 1785.—And Mr. Romé de

de Lisle possesses crystals in hexagonal laminæ, resembling the leaves of mica.

The white steatites of Briançon is composed of irregular, friable, and semi-transparent leaves. It often incloses crystals of steatites, of a white or greenish colour, which have the form of tetrahedral prisms.

The steatites of Corsica appears to be formed by fibres placed beside each other. It has a greenish colour, and no perceptible degree of flexibility.

The steatites of Bareith is grey, compact, and solid.

That of Queen Charlotte's Bay in New Zealand is striated, green, semi-transparent, and sufficiently hard to give fire with the steel.

3. The soap-stone of China is a steatite, often striated; but it is not more unctuous than those we have already mentioned.

The steatites of Briançon forms the basis of the vegetable red.

4. The lapis ollaris, or pot-stone, is only a variety of the steatites. It does not appear to me to differ from it, excepting in being harder.

Its colour is usually greyish; but it is sometimes blackened by bitumen.

Mr. Gerhard has observed that the lapis ollaris of Sweden effervesces with acids, and contains

tains calcareous earth; but this mixture is peculiar to it. Thoſe of Saxony, Sileſia, and Corſica do not contain it. The lapis ollaris may be wrought with the greateſt facility. In the country of the Griſons, in Corſica, and elſewhere, it is turned, and formed into veſſels which reſiſt the fire, and have not the inconvenience of our glazed pottery; it is from theſe uſes that it has obtained the name of Lapis Ollaris, Pot Stone, &c.

SPECIES III.

Pure Magneſia combined with ſomewhat more than its weight of Silex, one-third of Alumine, near one-third of Water, and more or leſs of Iron.

This mixture forms the ſerpentine. It has a great analogy with the preceding ſubſtances, but is diſtinguiſhed from them by a more evident degree of hardneſs; by the property of acquiring a more beautiful poliſh; and by a quantity of iron ſufficiently conſiderable to afford it a peculiar character.

The ſerpentine is whitiſh, greeniſh, blueiſh, or blackiſh; frequently marked with black ſpots; and ſometimes interſected with bands of various colours. Some ſerpentines are even tranſparent.

rent. The Royal Cabinet of Mines poſſeſs a ſpecimen whoſe ground is grey, and interſperſed with reddiſh ſemi-tranſparent and chatoyant ſpots.

Serpentine varies likewiſe in its texture.

It is compact, granulated, ſcaly, lamellated, or fibrous.

It takes the moſt beautiful poliſh.

The iron it contains is ſometimes obedient to the magnet.

Its ſpecific gravity is from 2.4 to 2.65.

It melts in a violent heat; but a leſs degree of fire hardens it.

Mr. Bayen, who has analyſed the ſerpentine, found it to contain, in the hundred parts, forty-one ſilex, thirty-three magneſia, twenty alumine, three iron, and alſo water.

Mr. Kirwan has obſerved, that the ſerpentine of Corſica contained more alumine, and leſs ſilex.

Mr. De Joubert poſſeſſes a ſpecies of ſerpentine which exhibits ſquare plates on its ſurface.

Mr. Dorthes has obſerved ſeveral varieties of the ſerpentines on our Mediterranean coaſts, and in the river of Herault, which receives them from the mountains of the Cevennes.

SPECIES IV.

Carbonate of Magneſia; Silex, Lime, Alumine and Iron.

This combination exhibits ſeveral varieties, which are known under the name of Aſbeſtos, Mountain Cork. Their texture ſerves to diſtinguiſh them; but the chemical analyſis confounds them together, and does not permit us to allow any other diſtinction than that of varieties.

VARIETY I.

Aſbeſtos.

This ſtone is uſually greeniſh; its texture is ſometimes fibrous and compact, and ſometimes membranaceous.

Near Bagnères de Bigorre, in the mountains of the environs of Baſſere, Meſſrs. Dolomieu and La Peyrouſe found cryſtals of aſbeſtos in rhomboidal parallelopipeds.

Aſbeſtos is rough to the touch, brittle and rugged. Its ſpecific gravity is from 2.5 to 2.8.

Fire renders it whiter and more brittle. It is infuſible by the blow-pipe, according to Kirwan; but the abbé Mongez affirms that aſbeſtos and amianthus are fuſible, and form an opake globule,

globule, which becomes bluiſh. It is difficultly ſoluble with ſoda; but more eaſily with borate of ſoda and the phoſphates of urine.

According to Bergmann, the aſbeſtos contains in the quintal from fifty-three to ſeventy-four parts ſilex, about ſixteen magneſia, from twelve to twenty-eight carbonate of lime, from two to ſix alumine, and from one to two iron.

VARIETY II.

Mountain Cork.

This name has been given on account of a ſlight reſemblance of this ſubſtance to cork. This ſtone is very light, membranaceous, flexible, and uſually of a yellow colour. It may be more eaſily torn than broken. The dioceſe of Alais affords very fine ſpecimens.

Among a very great number of ſtones of this nature, ſubjected to analyſis by the celebrated Bergmann, the ſiliceous earth was always found predominant; and after that the magneſian, which was never leſs than twelve parts in the hundred, nor more than twenty-eight.

SPECIES V.

Carbonate of Magnefia and Lime, Sulphate of Barytes, Alumine, and Iron.

This combination forms amianthus. It is compofed of long flexible fibres, parallel to each other, and very foft to the touch.

They are fometimes very white, but often yellowifh. The filaments may be feparated and detached from each other; and may be even twifted in any direction without danger of breaking them. Their flexibility is fo wonderful, that they may be formed into cloth. The ancients conftructed cloths of this kind, in which they burned the bodies of the dead; and by this means the afhes were collected without mixture of thofe of the fuel.

Mr. Dorthes found amianthus in tufts upon calcareous ftones thrown up by the fea, on which it was fixed with plants, corallines, gorgonia, &c. He believes, with reafon, that this amianthus did not originate upon the ftones, but that it was depofited by the water. He found likewife, on the coaft, balls of the amianthus of two or three inches diameter imitating ægagropiles, and formed by the intertwining of the threads of amianthus; and covered with a white

tophofe fubftance, of the nature of that which covers the gorgonia, and is the work of a fpecies of fea animalcule.

The fibres of amianthus are of various lengths. I have received fpecimens from Corfica, whofe filaments were very flexible, and eight inches long. That from the Pyrenean mountains has fhorter fibres.

Bergmann analyfed an amianthus from the vicinity of Tarento, of which 100 parts afforded 64 filex, 18.6 magnefia, 6.9 lime, 6 fulphate of barytes, 3.3 alumine, 1.2 iron.

GENUS IV.

Aluminous Mixtures.

Argillaceous or aluminous ftones are common enough. They are feldom poffeffed of more than a moderate degree of hardnefs, and are divifible in water. But the mixture of their principles is in fome inftances fo intimate, that they poffefs a very ftrong degree of confiftence.

SPECIES I.

Alumine, Silex, Carbonate of Lime, and more or lefs of Iron.

We may here place all the varieties of clay. Chemical analyfis exhibits, conftantly enough,

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the principles whofe mixture forms this fpecies; but the proportions among thefe conftituent principles vary fo much, that the varieties of clay are almoft infinite. Independent of the principles above enumerated, we fometimes find lime combined with clay, and fometimes even magnefia; and it will be eafy to form various fpecies, in proportion as the analyfis of thefe earths fhall become more perfect.

The argillaceous mixtures of which we propofe at prefent to fpeak, are characterized by the following properties:—They adhere ftrongly to the tongue, become dry, hard, and fhrink in the fire; are divided, and form a pafte, with water, in which ftate they may be eafily moulded and turned, &c. The clays in which the filiceous principle is moft abundant are the drieft, adhere lefs to the tongue, are lefs completely diffufed in water, and crack lefs when dried by the heat of the fire or the fun.

Moft clays contain iron; and this metal is ufually the principle of their colour. From the brownifh clay, in which iron is almoft in the native ftate, to the deepeft red, all the various fhades are owing to the feveral degrees of alteration in this metal. Thefe various changes are effected either at the furface of the globe by the immediate action of the air, which calcines the iron,

iron, or elſe in the bowels of the earth; in which laſt caſe, the effects ariſe from the decompoſition of water and of the pyrites. We may trace this beautiful work of nature in ſeveral pyritaceous ſtrata in our province; and on this ſubject reference may be had to my Memoir upon the Brown Red (Brun Rouge), printed by Didot by order of the province.

We ſhall direct our attention leſs to the ſeveral varieties of clay than to the uſes to which they are applied. The firſt of theſe uſes is to form the baſis of pottery.

Several ſpecies of pottery may be obſerved, which nevertheleſs differ from each other only in the degree of fineneſs of the earths made uſe of, and the care that has been taken in performing the various manipulations which they undergo.

1. The moſt common pottery is made with any kind of clay indiſcriminately, which is mixed with ſand, to render it more porous, and by this means more adapted to ſupport the heat.

Theſe veſſels would be penetrable by water, if they were not covered with a glaze.

The glazes of pottery are uſually made either with the ſulphureous lead ore called Alquifoux, and in England, Potters Lead Ore, or with the yellow copper ore. For this purpoſe,

these substances are reduced to powder, mixed with water, and the vessel, previously dried by a slight baking, is dipped in the mixture. The porous vessel absorbs the water, while its surface becomes covered with the pounded ore. The vessel is then carried to the furnace, and baked by a heat which vitrifies the ore upon its surface; and it is this metallic glass which forms the glaze of the potters, and is yellow or green, according to the metal made use of.

These glazes are all dangerous; because they are soluble in fats, oils, acids, &c.

The attention of intelligent manufacturers has been long directed to the methods of substituting in the place of these glazes, others which are not attended with the same danger.

We might, after the manner of the English, vitrify the surface of our pottery by means of sea salt thrown into the fire-place when the furnace is at a white heat; but this method is impracticable in most of our manufactories, because our fires are not sufficiently strong.

I have tried various methods to glaze pottery; and two among them have succeeded well enough to justify my publishing them. The first consists in mixing the earth of Murviel in water, and dipping the pottery therein: this done, they are suffered to dry; after which they

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are plunged into a ſecond water, in which levigated green glaſs is mixed. This covering of vitreous powder fuſes with the clay of Murviel; and the reſult is a very ſmooth, very white, and very cheap glazing.

The ſecond method conſiſts in immerſing the dried pottery into a ſtrong ſolution of ſea ſalt, and afterwards baking them. The trial which I have made in my furnaces gives me reaſon to expect that this method may be uſed in large works.

I have likewiſe obtained a very black glazing, by expoſing pottery ſtrongly heated to the fumes of ſea-coal. I have coated ſeveral veſſels in this manner, by throwing a large quantity of coal in powder into a furnace wherein the pottery was ignited to whiteneſs. The effect is ſtill more complete when the chimneys or tubes of aſpiration of the furnace are at that moment cloſed, and kept ſo for ſome minutes.

I have given an account of all theſe circumſtances, and many others, in a work preſented to the Royal Society of Sciences of Montpellier; in which I have proved, from the reſults of my experiments in the large way, that the beſt mixture of our own earths is capable of affording us the moſt beautiful and fineſt pottery of every kind.

2. Fay-

2. Fayence*. This does not differ from the pottery we have here ſpoken of, except in the degree of fineneſs of the earths uſed for its baſis, and the nature of its covering or glaze.

The glazing of fayence is nothing elſe, as is well known, but glaſs rendered opake by means of the oxide of tin. It is the glaſs called Enamel.

To make the fine white enamel of the potters, one hundred pounds of lead, thirty of tin, ten of marine ſalt, and twelve of purified potaſh, are calcined together. This mixture, after calcination and fuſion, produces a beautiful enamel, which is applied in the ſame manner as the glaze before ſpoken of.

Bernard de Paliſſy excelled in the art of fayencery; and it is to him that we are indebted for our firſt acquiſitions in this manufacture †.

3. The

* Diſtinguiſhed by us by the name of Delft Ware. T.

† I cannot reſiſt my inclination to inſert in this place a few circumſtances of the life of this great but unfortunate man, who lived in the 15th century. He was a native of the dioceſe of Agen, and his firſt employment was that of ſurveyor or draftſman of plans: but his taſte for natural hiſtory led him to abandon this employment; and he travelled for inſtruction over the whole kingdom, and Lower Germany. An accidental circumſtance threw into his hands a cup of enamelled pot-

 tery,

3. The fineſt pottery is known by the name of Porcelain ; it ought to be white, tranſparent, and of a fine grain.

The firſt porcelains were manufactured in Japan and China.

The celebrated Reaumur firſt undertook a capital ſeries of experiments to imitate theſe potteries: but, deceived by the ſemi-tranſparence and vitreous

tery ; and, from that time, his whole time and fortune were taken up in experiments on enamels. Nothing can be more intereſting than the narrative which he himſelf has given of his labours. He exhibits himſelf building and rebuilding his furnaces ; always on the eve of ſucceſs ; worn out by labour and misfortune ; the deriſion of the public ; the object of the angry remonſtrances of his wife ; and reduced to burn his furniture, and even the wood-work of his houſe, to keep his furnace going. His workman preſſes him for money : he ſtrips himſelf, and gives him his clothes. But at length, by dint of indefatigable labour, conſtancy, and genius, he arrived at the deſired degree of perfection ; which gained him the eſteem and conſideration of the greateſt men of his age. He was the firſt who formed a collection of natural hiſtory at Paris, and even gave lectures on that ſcience ; receiving half a crown from each of his auditors, under the obligation of returning it fourfold if any thing he taught ſhould prove falſe. The high reputation he acquired, and the obligations under which his countrymen ſtood indebted to him, were not ſufficient to defend him from the perſecutions of the League ; for Matthew De Launay, one of the greateſt fanatics, cauſed him to be dragged to the Baſtile at the age of ninety years. He ſignalized himſelf in his

vitreous appearance of porcelain, he imagined it to be a femi-vitrification, and attended only to the means of ftopping the procefs of vitrification at a certain ftage of its effect, or of caufing it to become reverfed. He fucceeded in his undertaking, by filling bottles with fand and gypfum, and expofing them to a potter's furnace. I have likewife produced the fame effect

his prifon by acts of firmnefs and heroifm. Henry the Third vifited him, and reprefented his fituation in thefe words: "My "good man, if you cannot reconcile yourfelf to the matter of "religion, I fhall be compelled to leave you in the hands of "my enemies."—Paliffy anfwered, "Sire, I was perfectly "ready to furrender my life for the glory of GOD. If this "action could have been accompanied with any regret, cer-"tainly it muft have vanifhed, after hearing the great King of "France fay, *I am compelled.* This, fire, is a fituation to "which neither yourfelf, nor thofe who force you to act con-"trary to your own difpofition, can ever reduce me; becaufe I "am prepared for death; and becaufe neither your whole peo-"ple, nor your Majefty, poffefs the power of forcing a fimple "potter to bend his knee before images."—Bernard De Paliffy was the firft who affirmed that calcareous mountains are the remains of fhells. He has exhibited fuch a degree of intelligence and fagacity in all his writings, that he deferves to be placed among thofe great men who are an ornament to our nation. The very form of his works exhibits a proof of original genius. They confift of dialogues between Theory and Practice. Practice is always the inftructor; and Theory is reprefented as a fcholar, proud of his own underftanding, but indocile and ignorant.

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by a very different procefs, though dependent on the fame theory. When I concentrate my oils of vitriol in the green glafs of our manufacture, that part of the retort which is continually ftruck by the rifing oil of vitriol becomes white, and lofes its tranfparence. This phenomenon conftantly takes place, whenever the fire is raifed fomewhat more than ufual. The retort preferves its form; but all its alkali is extracted, and there remains, only the quartzofe principle of a beautiful white colour, fomewhat cracked like the porcelain of Japan. As the decompofition commences at the interior furface, which is immediately acted on by the vapours, this furface is frequently rendered white, and difcoloured; while the exterior furface remains perfectly vitreous, and exhibits a ftriking contraft. For, when the interior furface of the glafs is infpected, it prefents a white covering applied againft a furface of glafs; forming, by the union of both, a thicknefs no greater than that of which retorts are ufually made.

Father Dentrecolles fent from China the fubftances ufed in the fabrication of porcelain: they are known by the names of Kaolin and Petunzé. Similar fubftances were foon found in France; and our porcelain manufactories, in a fhort time, equalled the moft beautiful productions

tions of this kind, and even exceeded them in the beauty of deſign and figure. The manufactory of Sèves is at preſent, without contradiction, the firſt in the world. Nothing can equal the beauty of its paintings, the regularity of deſign, and the elegance of form, which are given to the veſſels produced in this manufactory.

Four principal operations may be diſtinguiſhed in the manufacture of porcelain.—— 1. The preparation, the mixture of earths, and the working of the paſte. 2. The firſt baking, which forms the biſcuit. 3. The application and fuſion of the glaze and covering. 4. The art of painting, which demands a third baking, in order that the colours may be better combined, fuſed, and amalgamated with the glaze.

I have myſelf made very beautiful porcelain with the kaolin, which is found in veins in the granite of St. Jean de Gardonenque, and the field ſpar ſo common in our mountains of Cevennes.

The quantity of porcelain which is made in China is immenſe. There are five hundred furnaces, and near a million of men, employed at King-to-ching, a province of Kian-ſi.

Our clays poſſeſs other advantages likewiſe; they ſerve, in the fulling-mills, to clean and full

piece

piece goods. The beſt fullers earth is ſoft and ſoapy.

The name of tobacco-pipe clay is given to a white clay, which preſerves its whiteneſs in the fire, and reſiſts a violent heat.

The ſcaled earths, or terræ ſigillatæ, are clays upon which ſuperſtition has beſtowed chimerical virtues. They are impreſſed with a ſeal, for the purpoſe of deceiving the public with greater certainty and effrontery.

Almoſt all the marles, more eſpecially thoſe which are found in ſtrata, appear to me to be compoſed of the ſame principles. Much variation prevails with reſpect to the proportion of thoſe conſtituent principles, and more eſpecially with regard to the clay which predominates.

SPECIES II.

Alumine, Silex, Pure Magneſia, and Iron.

Mica, which reſults from the mixture of theſe principles, has been improperly confounded with talc. Mica is ſoft to the touch, but not greaſy like talc. It poſſeſſes in general a more brilliant and leſs earthy colour, if I may uſe theſe expreſſions.

The moſt uſual colour of mica is white or yellow,

low, inclining to red; but it has been found of a greenifh, red, brown, and other colours.

Its texture likewife varies: it is fcaly, lamellated, or ftriated.

It fometimes exhibits the form of a fegment of an hexagonal prifm.

It is ufually found mixed with feld fpar, quartz, fchorl, &c. It almoft always exifts in the primitive rocks. Its fpecific gravity is from 2.535 to 3.000 when charged with iron.—Kirwan.

The colourlefs mica is infufible. It is only partially foluble in foda, in which it becomes divided with effervefcence: it fufes in the borate of foda, and in the phofphates of urine, with fcarcely any effervefcence.

The coloured micas are fufible.—See De Sauffure.

The fragments of mica are employed, under the name of Cats Gold or Silver, according to the colour, as a fand for drying ink upon paper.

Its yellow colour, which confiderably refembles that of gold, often deceives the ignorant, who fuppofe that they have difcovered a mine of this precious metal when they find a few pieces of this ftone.

Mr. Kirwan obtained from one hundred parts of colourlefs mica, thirty-eight filex, twenty-

eight alumine, twenty magneſia, and fourteen oxide of iron.

SPECIES III.

Alumine, Silex, Magneſia, Lime, and Iron.

The mixture of theſe principles forms the horn-ſtone, or horn-blende of the Germans. This ſtone has a cloſe grain, is difficultly pulverized, and is ſlightly flattened under the hammer.

Its colour varies, which is either black or of a greeniſh grey; and its texture is in general either lamellated or ſtriated.

Its general characters are, partial ſolubility in acids without efferveſcence; a degree of hardneſs which never amounts to that of affording fire with the ſteel; a ſpecific gravity never leſs than 2.66, and frequently as high as 3.88; a ſtrong earthy ſmell, which it emits when breathed upon, or is moiſtened with hot water; a tenacity under the peſtil, &c.—See Kirwan, who diſtinguiſhes two varieties.

VARIETY I.

Black Horn-ſtone, Lapis Corneus Nitens Wallerii.

Its texture is either lamellated or grained. In the firſt caſe it is ſometimes ſo ſoft as to be capable of being ſcratched with the nail. Its ſurface is frequently of a ſhining, greaſy appearance; and its ſpecific gravity is from 3.6 to 3.88.

Mr. Kirwan found that the lamellated ſort contains thirty-ſeven parts ſilex, twenty-two clay, ſixteen magneſia, two lime, and twenty-three oxide of iron.

VARIETY II.

Horn-ſtone of a Greeniſh Grey Colour.

This variety is either of a granulated or ſtriated texture. Mr. Kirwan found its ſpecific gravity to be 2.683; it is harder than the preceding.

The pale greeniſh hone is of this quality. Its grain is cloſe; it emits an earthy ſmell, does not efferveſce with acids, nor ſtrike fire with ſteel. It contains, according to Kirwan, ſixty-five

five parts of ſilex in the hundred, and its ſpecific gravity is 6.664.

SPECIES IV.

Alumine, Silex, Carbonate of Magneſia, and of Lime with Iron.

This ſpecies, which comprehends the ſlate or ſchiſtus, does not appear to differ eſſentially from the preceding, ſince its principles are the ſame, and there is no other difference excepting what depends on the ſtate of the lime and magneſia; which in this laſt efferveſces ſlightly with acids, according to Kirwan.

The ſlate is an argillaceous ſtone, whoſe principal character is that of being diviſible into very thin plates, capable of being wrought, and of receiving a certain poliſh.

The colour of the ſlate is blue, of ſeveral degrees of intenſity; but this colour varies, and exhibits the following ſhades.

VARIETY I.

Blueiſh Purple Slate.

This is brittle, and of a lamellated texture; does not give fire with the ſteel; its ſpecific gravity is 2.876; it affords a very clear and ſilvery

ſound, when divided into plates of an uniform thickneſs; it ſlightly effervеſces with acids when it is reduced into powder, but not elſe.

It forms black ſcoriæ in a ſtrong fire. Soda aſſiſts its fuſion, and it is fuſed ſtill more eaſily with the borate of ſoda.

From one hundred grains of this ſlate Mr. Kirwan obtained forty-ſix ſilex, twenty-ſix alumine, eight magneſia, four carbonate of lime, and fourteen iron.

VARIETY II.

Black Slate.

This receives a conſiderably fine poliſh when rubbed. The powder which is detached is white, and ſlightly effervеſces with acids.

VARIETY III.

Blue Slate.

The blue ſlate contains leſs iron than the firſt variety. It is uſually hard, and of a very fine grain.

VARIETY IV.

Slate of a Pale White Colour.

It is leſs martial than the other varieties, and is more difficultly vitrified.

Slates

Slates are uſed to form tablets, and to cover the roofs of houſes.

SPECIES V.

Alumine, Silex, Pyrites or Sulphure of Iron, and Carbonate of Lime and of Magneſia.

The ſchiſtus which reſults from this combination is known by the name of Pyritous Schiſtus.

The pyrites are ſometimes diſperſed in the maſs, in the form of cubical cryſtals. Sometimes they are diſcovered only by analyſis, or by the ſpontaneous decompoſition of the ſtone.

The mountains which afford theſe ſchiſti appear to me to be marine depoſitions. Impreſſions of leaves, of fiſhes, and other characters, are frequently obſerved, which leaves no doubt of their origin.

The pyrites ſoon effloreſce when the concurrence of air and water aſſiſts their decompoſition; and the reſults then are ſulphuric ſalts, with baſes of magneſia, alumine, iron, and lime. When the ſulphate of alumine predominates, it is called aluminous ſchiſtus. Moſt of the alum ores wrought in Europe are of this nature. We have ſeveral in Provence which might be wrought; the ſchiſti of Vebron in the Gevandan, thoſe of

Curvalle in the Albigeois, afford much alum by their decompofition.

When the magnefian principle prevails, the efflorefcence confifts of Epfom falt. I have difcovered a mountain of this kind in Rouergue, in the neighbourhood of Saint Michael.

Thefe efflorefcences of alum or Epfom falt are always more or lefs abundantly mixed with the fulphates of iron and of lime; becaufe the fulphuric acid, which is formed by the decompofition of the pyrites, attacks and diffolves all the principles contained in the fchiftus.

The decompofition of thefe pyrites may be haftened by expofure to air, calcination, &c.

SPECIES VI.

Alumine, Silex, the Carbonates of Lime and of Magnefia, the Sulphure of Iron, and Bitumen.

This fchiftus does not differ from the foregoing, excepting in confequence of its being impregnated with bitumen.

It is ufually of a black colour, which it owes to its bituminous principle. Its confiftence is various; it is fometimes divifible in flakes, and its furface is either fmooth or rugged.

Thefe are the fchifti which ufually form the focus of volcanos. When their decompofition

is favoured by air or water, a prodigious heat is excited, hydrogenous gas is produced, which exerts itſelf againſt the ſurrounding obſtacles, and takes fire when it comes in contact with the air. It is this inteſtine labour which occaſions the ſhocks and tremulous agitations that precede the eruptions of volcanos. The action of volcanos muſt be more laſting and terrible, in proportion as the quantity of aliment and the focus are the more conſiderable.

We might, in ſtrictneſs, place the pit-coals here, as they do not differ from this ſchiſtus but in their greater abundance of the bituminous principle. We daily obſerve ſpontaneous inflammation to take place in heaps of pyritous coal, and the ſame effect happens even in the midſt of the veins which are wrought. Several examples of this may be pointed out in the kingdom of France. There even exiſts at Cranſac in Rouergue a true burning volcano. The mountain which contains the coal is prodigiouſly hot, and flames are perceived from time to time on its ſummit, which iſſue from its bowels. All theſe phenomena depend on the ſame cauſe; and from the ſmall artificial volcano of Lemery, to the terrible eruptions of Veſuvius, there is no other difference than what conſiſts in the magnitude of the cauſe.

When the earthy and metallic principles which form the bafis of bituminous fchifti, are ftrongly heated, and almoft vitrified by the fire which produces their decompofition, they conftitute volcanic products.

SPECIES VII.

Alumine, Silex, Lime, and Water.

This ftone, which is called Zeolite, was unknown to mineralogifts before the celebrated Cronftedt gave a defcription of it.

It is ufually of a femi-tranfparent white; but this colour is fometimes altered by metallic mixtures, and then it affumes all kinds of tinges.

The name of Zeolite has been given to it on account of its property of forming a jelly with acids. This property has even been confidered as exclufive and characteriftic. But Mr. Swab has very juftly obferved, in the year 1758, that all zeolites do not poffefs this property; and Mr. Pelletier has proved, in the twentieth volume of the Journal de Phyfique, that this property is not even peculiar to zeolites.

The exiftence of zeolites in certain lavas has induced fome naturalifts to confider them as produced by the decompofition of volcanic earths.

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The moſt beautiful zeolites come to us from the iſlands of Ferroe near Iceland. The form of this ſtone is conſtant. The radii which compoſe it diverge as it were from a central point, and are diſpoſed after the manner of a fan. The radius which terminates at the external ſurface, is found to exhibit a trihedral or tetrahedral pyramid.

The white zeolite affects two principal forms, the cube, and the tetrahedral priſm, ſometimes flattened, and terminated by an obtuſe tetrahedral pyramid.

Its ſpecific gravity is from 2.1 to 3.15.

The zeolite, expoſed to a ſtrong heat, dilates, and ſwells more or leſs, according to the proportion of water it contains, and at length melts into a porous ſcoria. Soda fuſes with it with effervescence; the borate of ſoda diſſolves it more difficultly; and the phoſphates of urine have ſcarcely any action upon it.

Bergmann obtained from one hundred parts of the red zeolite of Adelfort, 83 ſilex, 9.5 alumine, 6.5 pure lime, and 4 water.—Letters on Iceland, p. 370.

The white zeolite of Ferroe contains, according to Pelletier, fifty ſilex, twenty alumine, eight lime, and twenty-two water.—Journal de Phyſique, t. xx.

Meyer

Meyer obtained from a radiated zeolite 58.33 filex, 17.5 alumine, 6.66 lime, 17.5 water.

Mr. Kirwan rightly obferves, that the cryftallized fpecies contain more water than the others.

GENUS V.

Siliceous Mixtures.

We fhall place in this genus all the ftones which give fire with the fteel.

SPECIES I.

Silex, Alumine, Lime, and Iron intimately combined.

The mixture of thefe feveral earths forms the precious ftones or gems. All the varieties of gems depend on their colour, hardnefs, brilliancy, weight, the proportion of their conftituent parts, and their more or lefs intimate combination.

The numerous experiments of the celebrated Bergmann on precious ftones, have thrown the greateft light on their nature and compofition. The analyfes of Meffrs. Gerhard, Achard, &c. by exhibiting a ftrict identity of principles, have confirmed to us the refults of the famous Swedifh chemift; and it appears that no reafonable

able doubt can now be formed againſt thoſe principles.

As gems or precious ſtones are diſtinguiſhed in commerce by their colour, we ſhall preſerve this eſtabliſhed diſtinction.

DIVISION I.

Red Gems or Precious Stones—the RUBY, GARNET, &c.

1. The ruby is a precious ſtone of a fiery red colour, electrical by friction, giving fire with the ſteel, the moſt ponderous and the hardeſt of precious ſtones. It cryſtallizes in long hexahedral pyramids applied baſe to baſe, without an intermediate priſm.

Its ſpecific gravity is from 3.18 to 4.283. It is not vitrified in the fire without addition; and even reſiſts the action of the burning mirror. Flame urged by vital air eaſily fuſes it. It does not loſe its colour at the degree of heat which is ſufficient to melt iron. The borate of ſoda and the phoſphates of urine fuſe it.

One hundred parts of ruby contain, according to Bergmann, forty alumine, thirty-nine ſilex, nine lime, and ten iron.

The lapidaries, with whom hardneſs and tranſparency are the principal characters of ſtones,

ſtones, diſtinguiſh rubies of different colours; and the inhabitants of Pegu, who conſider the modifications of the colouring principle as different degrees of maturity, confound the topaz and the ſapphire under the name of rubies, of which they make three varieties.

The name of Spinelle ruby, or Balais ruby, is given to the ſame kind of ſtone, accordingly as its colour is of a pale or a deep red. This ruby cryſtallizes in octahedrons, and has a leſs ſpecific gravity than the oriental ruby.

2. The garnet is tranſparent when it is not overloaded with iron. It is in general obedient to the magnet, and of a yellowiſh red. The forms of the garnet appear to be derived from the rhomboidal parallelopiped, terminating in ſix equal rhombuſes.

They vary prodigiouſly in colour, and theſe varieties are—1. The red, or the carbuncle of Theophraſtus, according to Hill: it has a deep red colour. 2. The Syrian garnet, of a deep red ſlightly tinged with yellow. 3. The violet garnet, of a beautiful red mixed with violet.

All the garnets, whether denominated oriental or occidental, rank in one of theſe three claſſes.

Garnets change in the fire into an enamel of a blackiſh red. They are ſtrongly attacked by

the borate of ſoda, and the phoſphates of urine.

Garnet is found in ſmall grains in ſand ſtone (gres) or in ſchiſtus.

The texture of the garnet is lamellated, and its fracture vitreous.

Its hardneſs is inferior to that of other gems, but it exceeds that of rock cryſtal.

Its ſpecific gravity is from 3.6 to 4.188.

One hundred parts of garnet contain, according to Mr. Achard, 48.3 ſilex, 30 clay, 11.6 lime, 10 iron.

They ſometimes contain tin, or even lead; but this is ſeldom.—Bergmann.

DIVISION II.

Yellow Gems or Precious Stones—the TOPAZ, the HYACINTH, &c.

1. The topaz is of a gold colour. We are acquainted with two principal varieties: the occidental or Brazilian topaz, which has the beautiful deep yellow colour of gold; and the oriental, whoſe colour is lighter. The Saxon topaz reſembles the latter.

The oriental topaz loſes neither its colour nor its tranſparency in the porcelain furnace. The Brazilian topaz loſes its poliſh, its hardneſs, and its tranſparency, but without melting.

The

The oriental topaz affects the octahedral form.

The Brazilian topaz cryſtallizes in rhomboidal tetrahedral priſms, grooved longitudinally. They are terminated by two tetrahedral pyramids with ſmooth triangular faces.

The Saxon topaz exhibits long ſuboctahedral priſms, terminated by hexahedral pyramids more or leſs truncated at their baſe.

The ſpecific gravity of the oriental topaz is to that of water as 40,106 to 10,000; that of the Brazilian topaz is as 35,365 to 10,000.—See Briſſon.

The analyſis of one hundred parts of topaz afforded Bergmann forty-ſix clay, thirty-nine ſilex, eight carbonate of lime, and ſix iron.

2. The oriental hyacinth is of a reddiſh yellow colour.

It is uſually cryſtallized in the form of a rectangular tetrahedral priſm, terminated by two quadrangular pyramids with rhombic faces.

It loſes the brilliancy of its colours by the fire. M. Mongez conſiders it as infuſible by the blow-pipe. Mr. Achard affirms that he fuſed it in a wind furnace.

One hundred parts afforded Bergmann forty alumine, twenty-five ſilex, twenty carbonate of lime, and thirteen iron. That of which Mr. Achard

Achard has given the analyſis, contained 41.33 alumine, 21.66 ſilex, 20 carbonate of lime, 13.33 iron.

Hyacinths are found in Poland, in Bohemia, in Saxony, Velay, &c.

The hyacinth, rendered white by fire, is known by the name of Jargon. According to Mr. Lavoiſier, the hyacinth of Puy in Velay becomes white in fire urged by vital air.

Its ſpecific gravity, compared with that of water, is as 36,873 to 10,000.—See Briſſon.

DIVISION III.

Green Gems—the EMERALD, CHRYSOLITE, BERYL, &c.

1. The Peruvian emerald is of a green colour, electrical by friction, and cryſtallized in hexahedral priſms, truncated flat at each extremity.

The jaſpers, or green ſchorles, which are called praſe or mother of emerald, have often been confounded with the emerald.

Cryſtals of emeralds are frequently found inſerted in the gangues of quartz, and even of ſpar.

According to Mr. Sage, the more tranſparent emeralds are, the leſs their colour is changed in the fire. They become opake, and of a greeniſh white.

white. There are ſome which are reduced to enamel at their ſurface.

Mr. Darcet affirms, that in his experiments the emerald loſt its tranſparency, and moſt of its colour, but that its form was not changed. In the experiments at Vienna in Auſtria, the emerald melted in twenty-four hours; and at Florence it was ſpeedily fuſed by the burning mirror. Mr. De Sauſſure fuſed it by the blow-pipe into a compact grey glaſs; and Mr. Lavoiſier, with a ſtream of vital air, fuſed it into an opake milky bubble, whoſe internal part was greeniſh.

Its ſpecific gravity, compared with that of water, is in the proportion of 27,755 to 10,000.

One hundred parts afforded Bergmann ſixty alumine, twenty-four ſilex, eight lime, ſix iron.

Achard obtained 60 alumine, 21.26 ſilex, 8.33 lime, and 5 iron.

The emeralds which come from America are called occidental. Peru and the Brazils afford the moſt beautiful: they may be diſtinguiſhed by the colour; that of Peru is of a ſatin colour or appearance; the colour of the Brazilian is leſs lively.

The emerald is the ſofteſt of gems, and may be ſcratched by the topaz, the ſapphire, &c.

2. The chryſolite or peridot is of a green colour, ſlightly inclining to yellow.

Its

Its form is that of a hexahedral pyramid with unequal ſides, frequently ſtriated, and terminating in two hexahedral pyramids.

Mr. Sage affirms that this ſtone ſuffers no alteration in the moſt violent heat, its colour not being ſo much as altered : and the ſame chemiſt pretends that Wallerius did not operate on a true chryſolite, becauſe he affirms that it loſt its colour. Meſſrs. Lavoiſier and Erhmann fuſed it into a white, dirty, dull-coloured glaſs, by the aſſiſtance of vital air.

The ſpecific gravity of the Brazilian chryſolite is in proportion to that of water as 26,923 to 10,000.—Briſſon.

Maſſes of granulated chryſolite of various ſhades of green colour are found in the priſmatic baſaltes, and in ſeveral other volcanic products.

Theſe chryſolites are common in the volcanos of our province. Mr. Sage received from Auvergne an hexagonal priſm ſix inches in diameter, formed by the union of chryſolites of different colours.

3. The beryl, or aqua marina, is of a very blueiſh green.

The Saxon beryl, as well as that of Siberia, ſent to Mr. Sage by Mr. Pallas, exhibits hexa-

hedral, ſtriated, truncated priſms, of a lamellated texture.

The pure beryl decrepitates in the fire, loſes its tranſparence, and is fuſible by the blowpipe.

Its ſpecific gravity, in proportion to water, is as 35,489 to 10,000, for the oriental aqua marina; and 27,227 to 10,000 for the occidental. Briſſon.

A blue aqua marina, in long, flattened, tetrahedral priſms, grooved longitudinally, and united ſideways, is found among the granites of Spain, and on the declivity of Saint Symphorien, near Lyon. This ſtone is very common at Baltimore in America.

DIVISION IV.

Blue Gems—SAPPHIRE.

The colour of the ſapphire is a ſky-blue. The ſapphires of the brook d'Expailly have a green tinge, and change in the fire in the ſame manner as thoſe of the Brazils; whereas the oriental ſapphire is not changed in our ordinary furnaces. Mr. Erhmann cauſed the clear oriental ſapphire, and of a perfect blue, to run into an opake white globule by fire excited by the ſtream of oxigene.

The

The experiments of Meſſrs. Achard, Sage, D'Arcet, Erhmann, Lavoiſier, Geyx, Quiſt, &c. exhibit a variety of reſults in the analyſes of gems by fire, which can be attributed only to the manner in which they applied it; and more eſpecially to the very variable nature of the ſtones upon which they made their experiments.

The oriental ſapphire, and that of Puy, have the form of two very long hexahedral pyramids joined and oppoſed baſe to baſe, without an intermediate priſm. Mr. Sage ſaw a ſapphire in a rhomboidal cube, or ſix-ſided figure.

The ſapphire analyſed by Bergmann afforded him, per quintal, 58 parts alumine, 35 ſilex, 5 lime, and 2 iron.

Mr. Achard obtained from his analyſis 58.33 alumine, 33.33 ſilex, 6.66 lime, and 3.33 iron.

The ſpecific gravity of the ſapphire of Puy is in proportion to water as 40,769 to 10,000; that of the white oriental ſapphire is as 39,911; and that of the Brazilian ſapphire is as 31,307.

SPECIES II.

Silex, ſometimes pure, but oftener mixed with a very ſmall quantity of Alumine, Lime, and Iron.

This ſpecies eſſentially comprehends quartz and rock cryſtal.

The name of Quartz is given to the opake, or irregularly-figured vitrifiable ſtone; and that of Rock Cryſtal to the ſame ſtone cryſtallized. As the principles are nearly the ſame, this circumſtance naturally eſtabliſhes a diviſion of theſe ſtones into two claſſes.

DIVISION I.

Rock Cryſtal.

Rock cryſtal is a ſtone which exhibits ſilex in a ſtate more nearly approaching to purity than in any other natural ſubſtance yet obſerved. Mr. Gerhard has even found ſpecimens perfectly pure; but one hundred parts of cryſtal, ſtrictly analyſed by Bergmann, afforded him ninety-three parts ſilex, ſix alumine, and one lime.

The ordinary form of rock cryſtal is that of an hexahedral priſm, terminated by pyramids of

an equal number of ſides. The varieties of the ſeveral cryſtals may be reduced to this geometrical form.—Conſult Romé de Liſle.

Quartz cryſtallizes likewiſe in cubes. This form exiſts in various ſpecimens in the cabinets of Germany; and Mr. Macquart brought a ſpecimen with him to France.

The formation of this cryſtal appears to be owing to water, for we often find this fluid in the internal part of cryſtals; and they are evidently formed in the clefts and cavities of the primitive rocks, by the concurrence of this agent. But hitherto we have acquired very little knowledge reſpecting the circumſtances of this operation.

Bergmann obtained rock cryſtals by diſſolving ſilex in the fluoric acid, and ſuffering it to evaporate ſlowly. I left on the tables of my cabinet of mineralogy a receiver and a retort, in which I had made the acid of fluor; and when I had occaſion, two years afterwards, to inſpect this apparatus, I found the receiver almoſt entirely corroded, and its interior ſurface lined with a ſubtle powder, in which thouſands of rock cryſtals might be diſcerned.

Mr. Achard informed the public that he had obtained rock cryſtals by cauſing water impregnated with carbonic acid to filtrate through clay.

Mr. Magellan even preſented theſe cryſtals to the Academy at Paris; but the experiment, though repeated with the greateſt care by ſeveral chemiſts of the capital, was not attended with the ſame reſults.

Since that epocha, Mr. De Morveau, having incloſed rock cryſtals with a bar of iron in a bottle filled with gaſeous water, perceived a vitreous point fixed to the iron, which he ſuppoſed to be a rock cryſtal formed by this operation; ſo that he conſiders iron as a neceſſary intermedium to enable the carbonic acid to diſſolve quartz. This conſequence of Mr. De Morveau appears to agree with many facts which have been collected concerning the formation of rock cryſtal. We ſee it formed in ochreous earths; and I poſſeſs ochres in my collection which poſſeſs many of theſe ſmall two-pointed cryſtals.

It appears to me that it is not neceſſary to ſeek for a ſolvent for ſilex, in order to explain the formation of rock cryſtal. The ſimple diviſion of this earth appears to me to be ſufficient for the purpoſe; and I could bring numerous facts to ſupport this aſſertion.—See the article Cryſtallization.

It is proved by the obſervations and experiments of Mr. Genſſane, that a quartzoſe gurh is

is formed by ſimple tranſudation upon rocks of this nature; and the ſame naturaliſt has taken notice that, when the gurh is worn and depoſited by water, rock-cryſtals are formed. The waters which work their way through the quartzoſe rocks of the mine of Chamillat, near Planche les Mines in Franche-comté, form quartzoſe ſtalactites to the roof of the works, and even upon wood. The extremities of theſe ſtalactites which have not yet aſſumed a ſolid conſiſtence, are of a granulated and cryſtalline ſubſtance, eaſily cruſhed between the fingers.

In theſe cavities, called *craques* by the miners, a fluid gurh is often found, and ſtill oftener cryſtals ready formed. I have ſeen at Saint Sauveur, in the work of La Boiſſiere, near Bramebiaou, ſeveral incruſtations of gurh on the ſides of the gallery; and theſe ſpreading incruſtations were terminated by well-formed cryſtals, wherever the wall overhung, or deviated from the perpendicular. This gurh, when handled, and minutely examined, had no other appearance than that of a ſiliceous paſte of conſiderable purity.

The ſame effects appear to take place with regard to rock cryſtals, as with the calcareous ſpars. They are formed whenever their principles, in a ſtate of extreme diviſion and attenuation,

nuation, are ſuſpended by water, and depoſited with all the circumſtances which nature requires in order that cryſtallization may take place. I do not even think that it is neceſſary to recur to the property which water poſſeſſes of ſenſibly diſſolving ſilex, to explain the formation of theſe cryſtals: and we ſhall refer the formation of quartzoſe ſtalactites, agates, &c. to the ſame cauſe.

Rock cryſtal is frequently coloured by iron, in which caſe it aſſumes peculiar ſhades, which have been denoted under different names. We ſhall place them here as ſimple varieties.

VARIETY I.

Red Cryſtal—False Ruby.

It is frequently mixed with different ſhades. Its colour is deſtroyed by fire, according to Mr. D'Arcet. It is found in Barbary, in Sileſia, in Bohemia, &c.

When it is of a dull red, it is called the Hyacinth of Compoſtella.

VARIETY II.

Yellow Cryſtal—Bohemian Topaz.

It has ſometimes a tinge inclining to yellow; its

its colour is often internal only. It is found in Velay, near Briſtol in England, &c.

VARIETY III.

Brown Cryſtal—SMOKY TOPAZ.

This brown tinge varies from a light brown to a deep black. It is affirmed that they may be rendered clear by boiling them in tallow. See Journal de Phyſique, t. vii. p. 360.

It is found in Switzerland, in Bohemia, in Dauphiny, &c.

VARIETY IV.

Green Cryſtal—FALSE EMERALD.

This is the moſt ſcarce and the moſt precious of coloured cryſtals. It is found in Saxony and Dauphiny.

VARIETY V.

Blue Cryſtal—WATER SAPPHIRE.

It does not appear to differ from the true ſapphire, excepting in being leſs hard. I have ſeen a ſpecimen which had this colour. It is found in Bohemia, in Sileſia, and at Puy in Valay,

lay, which has caused it to be called the Saphire of Puy.

VARIETY VI.

Violet Crystal—the AMETHIST.

Its colour is more or less deep; and it assumes a considerable brilliancy by polishing. When the crystal is only half coloured, it is called *Prime d'Amethiste*. It loses its colour by a strong fire, according to Mr. D'Arcet. This crystal is found of sufficient magnitude to form columns of more than one foot in height, and several inches in diameter.

DIVISION II.

Quartz.

Those specimens of siliceous stone in which no regular form appears, and which we here comprehend under the name of Quartz, possess various degrees of transparency.

Its colour differs prodigiously; and it may be distinguished into varieties and shades perhaps more numerous than in rock crystal itself.

It seldom forms entire mountains, but almost always intersects, by veins more or less wide, the mountains of primitive schistus. At all events, I have

I have made this obſervation in every mountain of this kind which I have examined.

The blocks of quartz, detached by waters, are rolled, rounded, and depoſited in the form of large ſtones on the banks of rivers. The ſame ſtones, more attenuated, form the quartzoſe pebbles; and theſe, ſtill more divided, produce ſand.

This ſtone is very refractory. It is uſed as the baſis of bricks employed in the conſtruction of glaſs furnaces. For this purpoſe it is calcined to whiteneſs, and in that ſtate thrown into water. By this means it may be eaſily reduced to powder, and diſpoſed to form a combination with clay.

Quartz, well pounded, and uſed in the compoſition of bricks, does not equally reſiſt the impreſſion of fire, if the precaution of calcining it, and extinguiſhing it in water, has not been taken. I have obtained a proof of this fact, by employing the ſame kind of quartz in both ways.

This ſand forms an excellent mortar with good lime; and, when fuſed with alkalis, it produces a very beautiful glaſs.

SPECIES III.

Silex, Alumine, Lime, and Iron, intimately mixed.

The ſtate of fineneſs in the conſtituent principles, and their more or leſs intimate mixture or amalgamation, appear to us to eſtabliſh two diviſions among the ſtones of this ſpecies. We ſhall accordingly diſtinguiſh them into coarſer flints and finer flints. The firſt form gun flints, petroſilex, &c.; the ſecond comprehend agates, calcedonies, &c.

DIVISION I.

The Coarſer Flints.

In this place we ſhall arrange two ſtones which appear to differ only by a more or leſs evident degree of tranſparency. The ſilex, or flint properly ſo called, is ſemi-tranſparent, when very thin, as for example at its edges: the petroſilex has a more opake colour.

1. Gun Flint.—The gun flint gives fire with ſteel: its colour is uſually brown; and its ſurface very frequently exhibits a whiter colour than the middle, and leſs hard than the nucleus of the ſtone. This external part ſticks to the tongue,

tongue, and indicates a commencement of decompoſition.

The abbé Bacheley has aſſerted that marine productions, ſuch as polipiers, ſhells, &c. are capable of paſſing to the ſtate of gun flint. ——Journal de Phyſique, Supplement, 1782, t. xxv.

The ſpecific gravity of gun flint is from 2.65 to 2.7. This ſtone does not melt in the fire; but it becomes white and brittle by repeated calcinations.

The common brown ſilex afforded by analyſis to Mr. Wiegleb, per quintal, eighty ſilex, eighteen alumine, and two iron.

2. Petroſilex.—The colour of petroſilex is a deep blue, or a yellowiſh grey. It is interſperſed in veins through rocks; and from this circumſtance it derives its name.

Its ſpecific gravity is from 2.59 to 2.7.

It becomes white in the fire like gun flint; but it is more fuſible, for it flows without addition. Soda does not totally diſſolve it in the dry way; but the borate of ſoda, and the phoſphates of urine, diſſolve it without effervefcence.

Mr. Kirwan obtained from a petroſilex, uſed in the manufacture of porcelain by Mr. Lauraguais, ſeventy-two parts ſilex, twenty-two alumine, and ſix lime, in the quintal.

DIVISION II.

The Finer Flints.

This diviſion exhibits ſeveral ſtones, which, though diſtinguiſhed by names and a different value, are nevertheleſs only varieties of each other. We ſhall content ourſelves with enumerating the chief.

1. Agate.—This is a ſemi-tranſparent ſilex of a very fine body. Its texture is vitreous; and its hardneſs ſuch that it reſiſts the file, gives fire with the ſteel, and takes the moſt beautiful poliſh.

The agate, when expoſed to the fire, loſes its colour, becomes opake, and does not melt.

The varieties of agates are infinite. They are founded on the colour; and they are diſtinguiſhed into clouded, punctuated, ſpotted, iriſed, herborized, moſſy, &c. See Daubenton.—The name of Onyx is given to that kind of agate which is formed by concentric bands. Mr. Daubenton has proved that the agate which has received the name of moſſy, is really coloured by ſmall moſſy vegetations.

The pureſt agate is white, tranſparent, and nebulous. Such is the oriental agate, which beſides

besides appears as if it had protuberances or knobs on its surfaces.

Its specific gravity is 2.64. I consider the agates, and the other flints concerning which we shall proceed to treat, as quartzose stalactites. The sides of geodes which are agatized, and the strata of those flints which are found in places where infiltrations produce rock crystals, appear to me conclusive in favour of this doctrine. The agates have the same relation to quartz as the alabasters to calcareous stones, and the theory of their formation is the same. Mr. Dorthes has exhibited many proofs of this theory, respecting the formation of these stones.

2. The Opal.—The semi-transparent agate of a milky whiteness, which exhibits a glittering, changeable, internal colour of a blue, red, and green tinge, is known by the name of Opal. That which comes from Hungary has a kind of greyish clay for its gangue. The most beautiful opal is the oriental opal; sometimes called the spangled opal, because its colours appear like equal spots distributed over its whole surface. These opals have received various names, according to the colours they reflect.

The chatoyant stones, or such as vary their colour according to the position of the light,

light, and the eye of the obſerver, are varieties of the opal. Such are the giraſol, the cat's eye, the fiſh's eye.

The reflected rays of the giraſol are weak, blueiſh, and mixed with an orange yellow. This ſtone has been found in the lead mines of Chatelaudren in Britanny. The moſt obvious character of the giraſol is, that it exhibits in its internal part a luminous point; and reflects the rays of light in whatever poſition it may be turned, when it is cut into a globe or hemiſphere.

The cat's eye has a point near the middle, from which proceed, in a circle, greeniſh traces of a very lively colour. The moſt beautiful ſtones of this kind are of a grey and mortdoré colour. They come from Egypt and Arabia.

The fiſh's eye does not differ from the cat's eye excepting in its colour, which is blueiſh: it is found at Java.

3. Calcedony.—The calcedony is a ſemi-tranſparent agate of a milky whiteneſs, differing from the foregoing in not poſſeſſing the chatoyant property, or changeableneſs of colour.

It has been found in the mines of Cornwall, in ſtalactites of ſingular elegance. Theſe calcedonies are almoſt always covered with protu-

berances

berances like the ſtalagmites. The protuberances appear to be formed by the ſucceſſive appoſition of ſeveral ſtrata or coatings.

In Monte Berico, in the territory of Vicenza, geodes of calcedony are found which incloſe water. They are called Enhydria.

I poſſeſs, in the Mineralogical Cabinet of the province, calcedonies of Auvergne, which appear to be cryſtallized like rock-cryſtal. The cryſtals have all the fat and unctuous appearance of the ſame balls which are diſperſed on the rock; but, when they are broke, it is ſeen that the appearance aroſe from a covering of calcedony over the cryſtal of quartz.

Mr. Bindheim analyſed calcedony, and found, in the centenary, 83.3 ſilex, 11 lime, 1.6 alumine, and a ſmall quantity of iron.—Schrift. Natur. For. Free. t. iii. p. 429.

Mr. Darcet did not ſucceed in fuſing calcedony, but it loſt its colour.

Calcedony has often a ſhade of blue, yellow, or red.

Mr. De Carozy and Mr. Macquart obſerved in Poland the transformation of gypſum to the ſtate of calcedony.—See the Eſſai de Minéralogie par M. Macquart, premier mémoire.

4. Cacholong. The white and opake calce-

dony is known by the name of Cacholong. Its texture reſembles that of quartz, and it becomes white in the fire. This ſtone is capable of a fine poliſh. It is found on the banks of a river named Cach, near the Kalmouks of Bucharia, in whoſe language the word *cholong* ſignifies ſtone.

An imaginary value has been given to a modification of the cacholong, which has the property of becoming tranſparent after having been plunged in water. This is called Hydrophanes, Lapis Mutabilis, Oculus Mundi. Mr. Dantz brought hydrophanes to Paris, which became tranſparent when plunged in water.

Mr. Gerhard, on the 28th of Auguſt 1777, read to the Academy of Berlin Obſervations on the Hydrophanes. He found that this ſtone contained two-thirds of clay, and one-third of ſilex. This celebrated naturaliſt affirms that the hydrophanes was known to Boyle, who ſaw one of them about the ſize of a pea ſold in London for two hundred pounds ſterling.

The hydrophanes is fuſible in the fire. Soda diſſolves it with efferveſcence; the borate of ſoda, and the phoſphates of urine, without effervеſcence.

5. Carnelian. Sardonyx. The carnelian is a ſpecies of agate, nearly tranſparent. It is called

Car-

Carneole when it has the colour of fleſh. Its hardneſs varies prodigiouſly. Thoſe which are white or yellowiſh are not ſufficiently hard to give fire with the ſteel. When ignited it loſes its colour, and becomes opake. The moſt beautiful ſpecimens reſemble the garnet. Its ſpecific gravity is from 2.6 to 2.7.

The ſardonyx is a ſemi-tranſparent ſilex, of an orange colour, more or leſs deep. It is knobbed like the calcedony; and poſſeſſes the hardneſs and ſpecific gravity of that ſtone. Its habitude in the fire reſembles that of the agate. In the Royal Wardrobe of France there are veſſels of ſardonyx of an aſtoniſhing magnitude and beauty. The famous murrhine vaſes were of ſardonyx. Sage, t. ii. p. 163.

SPECIES IV.

Silex, Alumine, and Iron.

Jaſper is one of the hardeſt ſtones we are acquainted with. It is ſuſceptible of the fineſt poliſh; and its colour varies prodigiouſly, which has occaſioned it to receive the names of Sanguine Jaſper, Green Jaſper, Flowered Jaſper, &c.

Mr. Wedgwood aſſured Mr. Kirwan that jaſper hardens in the fire without melting; and

Mr. Lavoiſier could not obtain a perfect fuſion by the aſſiſtance of oxigenous gas. The ſurface only becomes vitreous.

Mr. Gerhard aſſerts that ſome ſpecies are fuſible; and Mr. Kirwan attributes this property to the mixture of lime and iron which produces the fuſion.

Its exceſſive hardneſs has induced the ſavages of Canada to avail themſelves of it in the fabrication of the heads of javelins.

Mr. Dorthes has found, among the worn ſtones of the Mediterranean ſhore, javelin-heads of porphyry, jaſper, horn-ſtone, ſchorl, variolite, &c. probably fabricated by the ancient inhabitants, the Gauls.

Theſe javelin-heads are commonly known by the name of Thunder-ſtones, and are diſtinguiſhed by lithologiſts by the name of Ceraunites.

SPECIES V.

Silex, Alumine, Lime with a ſmall portion of Magneſia, and Iron.

This ſpecies comprehends all the ſchorles, and moſt of the volcanic products. As the tourmaline is evidently nothing more than a variety of the ſchorl, we ſhall place it here, though analyſis

lyſis has not diſcovered an atom of magneſia in it, and the nature of its principles confounds it with precious ſtones. Moreover, by placing it between theſe and the ſchorls, it poſſeſſes a ſituation aſſigned to it as well by its natural characters as by its conſtituent principles.

I. The Tourmaline.—This ſtone poſſeſſes the tranſparency of the ſchorl. Its appearance and fracture are vitreous, its texture lamellated, its hardneſs ſo conſiderable as to cut glaſs. When heated to the two-hundredth degree of Fahrenheit, it becomes electrical: a ſtronger fire deprives it of this property. It is fuſible by the blow-pipe, with ebullition: the pure tourmaline was melted into a black glaſs, in the experiments of Mr. Lavoiſier.

Tourmalines have been found in the iſland of Ceylon, in Tyrol, and in Spain.

Its form is that of a nine-ſided priſm, terminated by two flat trihedral pyramids. Mr. De Joubert poſſeſſes one whoſe priſm is ſeven inches and a half long, and eleven inches in circumference.

The priſmatic tourmaline has no electric effect but according to the direction of its column; the ſphere of activity of the Spaniſh tourmaline is more extenſive than that of Tyrol.

The valuable reſearches of Bergmann upon

 this

this ſtone may be conſulted in his diſſertation concerning its analyſis. Mr. Tofani has annexed a ſet of intereſting notes to his tranſlation of this work.

The reſults of Bergmann's analyſis exhibit its component parts in the following proportion;

1. The tourmaline of Teyrol contains alumine forty-two, ſilex forty, lime twelve, iron ſix.

2. The tourmaline of Ceylon, alumine thirty-nine, ſilex thirty-ſeven, lime fifteen, iron nine.

3. The tourmaline of Brazil, alumine fifty, ſilex thirty-four, lime eleven, iron five.

The ſpecific gravity of the tourmaline of Ceylon is 30,541, that of Spain and of Teyrol is 30,863, water being 10,000.—See Briſſon.

II. Schorl. The diſtinct properties of ſchorl are, an appearance of ſemi-vitrification, fuſibility in a moderate fire, and hardneſs approaching to that of cryſtal.

There are few ſtones which exhibit a greater variety of form or colour.

They enter into the compoſition of porphyry, of ſerpentine, of granite, and are very frequently found with the magneſian ſtones.

We ſhall diſtinguiſh the ſchorls into cryſtallized and irregularly-ſhaped ſchorls.

A. All

A. All the varieties which depend upon colour may be reduced to four.

1. Black Schorl.—The black ſchorl is found chiefly in granites. It has almoſt always the form of priſms more or leſs perfect. The number of ſides of theſe priſms is various: they are ſometimes grooved; they ſometimes terminate in trihedral obtuſe pyramids, placed in contrary directions; in ſome places they are found ſeveral inches long, and the union of theſe priſms frequently forms groupes of ſeveral inches in diameter. Their black colour is more or leſs deep. When urged by fire, they become reſolved into a black uniform glaſs of an imperfect fluidity like paſte.

The analyſis of the black priſmatic ſchorls of Gevaudan afforded me, per quintal, fifty-two ſilex, thirty-ſeven alumine, five lime, three magneſia, and three iron.

2. Green Schorl.—This variety exhibits the ſame form, and the ſame modifications; but the moſt common of its cryſtallizations is that of a tetrahedral priſm, terminating in ſhort pyramids likewiſe tetrahedral.

3. Violet Schorl.—This variety was diſcovered in 1781 by Mr. Schreiber, below the Grotto of Aunis, ſituated at the diſtance of one league from Bourg D'oiſan in Dauphiny. Mr. De la

Peyrouſe likewiſe found it at the Peak of Dretliz, in the Pyrenean Mountains.

This ſchorl poſſeſſes a certain degree of tranſparency. It is cryſtallized in rhomboides; its texture is lamellated; two of the rhomboidal planes of each pyramid have their faces ſtriated parallel to each other.

Schorl loſes its colour in the fire, and one thirteenth of its weight; it becomes of a greyiſh white: and with a ſtronger degree of heat it ſwells up, ſubſides, and forms a black enamel.

Its ſpecific gravity is 32,956, according to Briſſon.

4. White Schorl.—This variety has been found in the mountains of Corſica, Dauphiny, and the Pyrenees. It is of an opake white colour, and vitreous appearance; and is found in cryſtals on the ſurface of certain ſtones of the nature of lapis ollaris. I have ſeen a layer of this ſchorl between amianthus and the lapis ollaris. It melts in the fire into a white enamel.

The analyſis of this ſchorl from the Pyrenean Mountains afforded me, per quintal, fifty-five parts ſilex, twenty-two alumine, thirteen magneſia, and ſeven lime.

B. The ſchorl in connected maſſes nearly approaches the jaſper in its external characters. It may be diſtinguiſhed however by its fracture, which

which is of a dryer grain, and exhibits a diſpoſition to cryſtallization. This ſtone ſerves as the baſis to ſeveral porphyries. The variolite of Durance, a ſtone ſingular on account of the ſuperſtitions to which it has given riſe, is a ſchorl in the maſs, covered with grains of the ſame nature as the ground, but of a clearer green.

Mr. Dorthes has obſerved variolites on the coaſt of our Mediterranean ſea; and affirms that this ſtone in its decompoſition undergoes changes of colour, which ſucceed each other in the order of the ſolar ſpectrum.

III. Volcanic products.—The principal products of volcanos are baſaltes, lava, and terra pozzolana. Theſe ſubſtances are abſolutely of the ſame nature; but they are principally diſtinguiſhed by the name of Baſaltes when their form is regular. When they have no determinate figure, they are denominated Lavas; and when conſiderably attenuated they are diſtinguiſhed by the name of Terra Pozzolana.

Baſaltes is diſtinguiſhed into the priſmatic baſaltes with a number of ſides, from three to ſeven; the baſaltes in tables; and the ſpherical baſaltes.

Lava is diſtinguiſhed into compact lava, porous lava, twiſted lava, lava in tears, &c.

Several naturaliſts have claſſed the baſaltes with

with the ſchorls, and ſome of them have aſſigned the ſame origin to both. It appears nevertheleſs to be generally agreed that baſaltes is a product of fire.

It ſometimes differs from ſchorls in its chemical analyſis, and alſo in the circumſtance of its not always affording magneſian earth.

The colour of baſaltes is of a deep green, almoſt conſtantly covered or enveloped with a ferruginous cruſt leſs black than the internal part. The iron is in the ſtate of ochre.

Its form is conſtantly priſmatic, which is the natural effect of the contraction which it ſuffers in cooling.

Baſaltes is converted by fire into a moſt beautiful black glaſs. This property, which is admitted by every chemiſt, induced me to fuſe it, and blow it into bottles.

The attempt was perfectly ſucceſsful at the glaſs-houſe of Mr. Gilley of Allais, and at that of Mr. Giral of Erepian. I ſtill preſerve the firſt veſſels which were blown of this ſubſtance: they are of the moſt beautiful black, aſtoniſhingly light, but without tranſparency. Encouraged by this firſt ſucceſs, I requeſted Mr. Caſtelveil, the proprietor of another glaſs-houſe, to undertake ſome experiments; and in conſequence of various trials we ſucceeded in fabricating bottles

of

of an olive green, in which the moſt extreme lightneſs, and a truly aſtoniſhing degree of ſolidity, were united. Pounded baſaltes, ſoda, and ſand, in nearly equal proportions, formed their compoſition. The properties of theſe bottles, as proved by my own experiments, as well as by thoſe which Mr. Joly De Fleury, at that time comptroller-general, ordered to be made, render them of the greateſt value in commerce; and Mr. Caſtelveil was unable to ſupply the numerous orders he received. This manufacture ſupported itſelf with ſucceſs for two years: but at the end of that time the ſuperiority of the bottles ceaſed to be the ſame; the manufacturer received the reproaches of the conſumer; this ſuperb eſtabliſhment gradually fell off, and was at length abandoned.

Since that period I have made ſeveral experiments in the large way, from which I have obtained reſults that may be of ſervice to ſuch as are deſirous of following this manufacture.

1. The nature of the combuſtible uſed in glaſs-houſes has a prodigious effect in modifying the reſults of experiments. The ſame baſaltes which Mr. Caſtelveil conſidered as too refractory in his furnace heated by wood, was found of too fuſible a nature by Mr. Giral, who was in the habit of uſing pit-coal in his glaſs works. The

former manufacturer accordingly made his glafs by adding foda to the lava, whilft the latter mixed it with a very refractory fand.

2. The fame lava, fufed without addition, may be blown in one glafs-houfe, and not in another. This irregularity appeared to me at firft to depend effentially on the fkill of the workmen; but I have been fince convinced that it is totally independent of that circumftance.

In a furnace which is ftrongly heated, the fufed lava fometimes becomes fluid like water, and drops from the iron tube as foon as it is collected. The fame lava, when fufed in other furnaces, will preferve a fufficient degree of confiftence to admit of being blown. I am myfelf well affured that the lava might be wrought in any glafs-houfe whatever, provided the moment was feized in which the pafte was neither too fluid nor too thick to be wrought; but thefe attentions are too delicate, and too minute, to be obferved in works in the large way.

3. The hardeft bafaltes affords the moft beautiful glafs. When it is contaminated with foreign principles, fuch as the nodules of lime, the glafs is brittle, and has not a fufficient connection of its parts. This circumftance, in my opinion, was the caufe of the bad quality of the glafs,

glaſs, which produced the failure in Mr. Caſtelveil's manufactory.

4. I have ſeen very hard baſaltes interſperſed with black infuſible points, inſomuch that theſe points became enveloped in the vitreous paſte without any perceptible alteration. The volcanic mountain of Eſcandorgue near Lodeve afforded me this variety of baſaltes.

In the article Verrerie of the Encyclopédie Méthodique, may be ſeen the various reſults which we have obtained with Mr. Allut, in ſeveral experiments made in common in the royal glaſs works of Bouſquet and elſewhere.

I ſhall conclude, from the obſervations which my experiments have hitherto afforded—

1. That lava may be uſed as a flux in glaſs-houſes to diminiſh the conſumption of ſoda. This is the ſingle purpoſe I at that time propoſed to myſelf, and I have clearly accompliſhed it. 1. By the reſults of experiments which have ſhewn that refractory ſand becomes fuſed in the glaſs furnace by a mixture of lava. 2. By the effects obtained in all the works in the large way, in which the addition of lava permitted a diminution in the proportion of ſoda.

2. It is very difficult to eſtabliſh a rigorous proceſs, applicable to all circumſtances, by which lava may be wrought without addition. My

bottles into which the lava entered as a component part, were ſcarcely known, before it was publiſhed that they were formed of lava without addition; nothing more being ſaid to be required than to fuſe the lava in order to form bottles. This ſtrange report affected me very little in the principle; becauſe I had neither ſpoken, written, nor printed any thing which was capable of giving authority to ſuch an error: and I was content to reply to all perſons who demanded information, by informing them that experience had taught me that an addition of lava diminiſhed the proportion of ſoda in the compoſition of glaſs, and that this new principle rendered the bottles lighter and ſtronger.

3. That the only advantage which can be derived from fuſing lava without addition, is to pour it out into moulds, to form paving ſtones, chimney jams, &c. The facility with which it is fuſed by the aſſiſtance of pit-coal, would render theſe works of ſmall expence; and it might eaſily be decorated by incruſting it with metallic colours.

4. That the difference in the nature of volcanic products produces ſuch a variety in the reſults of their fuſion, that I conſider it as impoſſible to aſſign a conſtant and invariable proceſs, by which the ſame reſult may infallibly be

be obtained. This circumſtance renders it neceſſary to make preliminary trials in all caſes wherein it is intended to uſe baſaltes in the fabrication of bottles.

The baſaltes has been conſidered as ſimilar to a ſtone known by the name of Trapp: it reſembles it in ſeveral eſſential properties; the colour, form, weight, and the nature of the component parts of each, appear to authorize us in confounding them together, as Bergmann has proved by the fine compariſon he has made of theſe two ſtones, in his analyſes of the volcanic products of Iceland. But this ſame chemiſt has ſhewn that they differ in ſeveral other points of view.

The trapp exhibits no character which can give ground to ſuſpect that its origin is volcanic; it is found in Sweden, in the primitive mountains, and upon ſtrata of granite and ſchiſtus, and ſometimes even upon banks of calcareous ſtone.

The trapp of the mountains of Weſtrogothland is uſually in the form of ſquare irregular cube; and it is indebted for its denomination to this reſemblance to the ſteps of a ſtair-caſe. It likewiſe exhibits the form of a triangular priſm, though ſeldom; and ſometimes it reſembles immenſe columns.

The trapp afforded Bergmann the same principles, and nearly in the same proportion, as the basaltes. The difference is scarcely the hundredth part; and this variation is frequently found in pieces of the same basaltes.

SPECIES VI.

Silex, Lime, Magnesia, Iron, Copper, and the Fluoric Acid.

This combination forms the chrysoprase. Its colour is a semi-transparent apple green, and it is harder than the fusible spars and quartz of the same colour.

The fire deprives it of its green colour, renders it white and opake, and forms by the assistance of vital air, a compact and milky globule.—See Erhmann.

Mr. Achard obtained, in the quintal of this stone, 95 parts silex, 1.7 lime, 1.2 magnesia, 0.6 copper.

SPECIES VII.

Silex, the blue Fluate of Lime, with the Sulphate of Lime and Iron.

This singular combination forms the Lapis Lazuli, or Azure Stone.

Its colour is of a beautiful opake blue, which it preserves in a strong heat, and does not suffer any alteration in this respect by the contact of air.

The

The powder of this ſtone makes a ſlight effervefcence with acids; but after calcination it forms a jelly with acids, without exhibiting any previous effervefcence.

The powder of this ſtone forms the valuable colour known by the name of Ultramarine. The price of this colour is proportioned to its intenſity; and its value is accordingly leaſt when it is mixed with pyrites, becauſe theſe bodies diminiſh the vivacity of its colour.

This ſtone affords water by calcination, and when diſtilled with the muriate of ammoniac, it forms martial flowers; which proves, according to Mr. Sage, that its colour is owing to iron.

The azure ſtone is fuſed by a ſtrong heat into a whitiſh glaſs; and by the aſſiſtance of oxigene it forms a white tranſparent globule inclining to green, without internal bubbles, and not obedient to the magnet.

The ſpecific gravity of the lapis lazuli of Siberia is 29,454.—See Briſſon.

Plates of the lapis lazuli may be ſeen upon almoſt all richly decorated altars; it is likewiſe made into toys.

Margraff obtained from this ſtone calcareous earth, gypſum, iron, and ſilex. Mr. Rinmann has diſcovered that it contains the fluoric acid.

SPECIES VIII.

Silex, Alumine, Barytes, and Magnefia.

This ftone is known by the names of Feld Spar, Rhomboidal Quartz, Spathum fcintillans, Petuntze.

It very frequently forms one of the principles of granite, and the cryftals, which are found feparate, arife from the decompofition of this primitive rock.

The texture of feld fpar is clofe, lamellated, and it is lefs hard than quartz.

It fufes without addition into a whitifh glafs. I have neverthelefs obferved a very great variety in the feld fpars, with regard to their habitude in the fire. That of Avene, which is in the form of whitifh cryftals mixed with quartz, afforded me a tranfparent glafs of extreme hardnefs by the fimple addition of one-third of lime: whereas that of Efperon, treated in the fame manner, did not exhibit the fmalleft fign of fufion.

The fpecific gravity of white feld fpar is 25,946.—See Briffon.

Feld fpar exhibits feveral varieties in its form and colour.

Moft of the pieces of feld fpar inclofed in granite

granite have a rhomboidal form; and when this primitive rock becomes decompoſed, the cryſtals of feld ſpar are detached, and remain confounded with the rubbiſh. The granites of our province, almoſt all of them, contain theſe cryſtals, ſome of which are an inch and a half in diameter.

Feld ſpar has been found cryſtallized in tetrahedral priſms, terminating in pyramids with four ſides.

I poſſeſs ſome ſpecimens of feld ſpar of Auvergne, whoſe tetrahedral priſms are flattened and terminated by a dihedral ſummit.

The principal ſhades of colour in feld ſpar are white, roſe-colour, and chatoyant, or of changeable colours.

The white tranſparent feld ſpar is very rare; there is a piece in the Royal Cabinet of the Mineral School, which comes from Mount St. Gothar.

One hundred parts of white feld ſpar contain about ſixty-ſeven ſilex, fourteen alumine, eleven barytes, and eight magneſia.

The roſe-coloured feld ſpar is not very ſcarce. Our mountains exhibit much of it. It abounds with iron, which is in the ſtate of ochre. Some experiments have ſhewn me that this variety is more fuſible than the others. My analyſes have

even exhibited a larger portion of magnefia; and its confiftence appears to me to be lefs firm than that of other fpecimens.

Feld fpar is compofed of rhomboidal laminæ, which give it the property of exhibiting various colours, in a greater or lefs degree. Large pieces of feld fpar have been found on the northern coaft of Labrador, worn down by the waters into a round form, of a blueifh grey colour, and exhibiting the moft agreeable change of colours, according to the variation of pofition. The colours are a beautiful celeftial blue, fhaded with green. This ftone is known by the name of Labrador Stone. Granites are frequently found in which the feld fpar exhibits its changeable colours without being wrought.

CLASS III.

Concerning the Mixture of Stones among each other. Stony Mixtures. Rocks.

The mixture of the primitive earths with each other form the ftones we have hitherto treated of; and thefe ftones, united and connected together, or as it were joined by a cement, conftitute the numerous clafs of pebbles or ftones, concerning which we fhall proceed to treat. It is evidently feen that the mixture of various

ftones

ſtones has been produced, either by revolutions which have reverſed and confounded the whole ſurface of countries, or by the action of waters, which have ſucceſſively formed the ſtrata of rounded flints ſpread over the ſurface of the globe, and have afterwards depoſited in their interſtices that earthy matter which has connected them together. Theſe mixtures have afterwards acquired a degree of hardneſs; and at length appeared to form one ſingle ſubſtance.

We ſhall eſtabliſh our genera upon the preſence of ſuch ſtones as predominate; and the ſpecies will be deduced from the variety of ſtones mixed with that which determines the genus.

GENUS I.

Rocks formed by the mixture of Calcareous Stônes with other Species.

Though the baſis of calcareous ſtones enters into the compoſition of the greater part of lithologic ſubſtances, we find few rocks which can be ranged in this claſs.

SPECIES I.

Carbonate of Lime, and Sulphate of Barytes.

Mr. Kirwan obſerved compound ſtones in Derbyſhire, formed of chalk intermixed with nodules of ponderous ſpar.

SPECIES II.

Carbonate of Lime and Mica.

The green marble or Cipolin of Autun is of this kind. It is compoſed of eighty-three parts carbonate of lime, twelve green mica, and one iron.—Journal de Phyſique, t. xii. page 55. Calcareous ſtones are found in Italy, which exhibit brilliant ſpecks of mica, and are known by the name of Maſigno.

SPECIES III.

Mixtures of Calcareous and Magneſian Stones.

Sulphate of lime, fluate of lime, and carbonate of lime are found mixed with ſteatites, ſerpentine, talc, amiantus, and aſbeſtos. Such is, for example, the white marble interſperſed with ſpots of ſteatites, and deſcribed by Cronſtadt.

SPECIES IV.

Calcareous Stones, and Fragments of Quartz.

Quartz is ſometimes found in a calcareous cement. Sweden and Siberia exhibit ſeveral marbles which give fire with the ſteel. The calcareous grit, ſo common in the ſouthern part of our kingdom, is of this ſpecies. The ſand is compoſed of fragments of quartzoſe flints, rounded and connected by a calcareous gluten or cement. By digeſtion of grit-ſtone in an acid, the calcareous cement becomes diſſolved, and the proportion which the ſand bears to the whole may then be eaſily determined.

This grit-ſtone is ſeldom hard enough to be uſed in building, or in paving.

At Nemours, and at Fontainbleau, this ſtone has been found cryſtallized in perfect rhomboides: the cabinets of naturaliſts are enriched with ſuperb ſamples of this kind.

Lime-ſtone has likewiſe been found ſerving as a cement for feld ſpar, ſchorl, &c.; but this is ſomewhat rare.

Mr. De Sauſſure has deſcribed a ſtone whoſe elements are quartz and ſpar.

Our ſhores afford pebbles of hard marble of

 a light

a light-grey colour, interſperſed with feld ſpar and quartz.—See Dorthes.

GENUS II.

Compound Stones formed by the Mixture of Barytic Stones with other Stones.

As ponderous ſpar is of conſiderable ſcarcity, and is almoſt always found alone, this genus will not be numerous.

SPECIES I.

Ponderous Spar mixed with a ſmall Quantity of Calcareous Spar.

The dioceſes of Alais and of Uzes afforded me this ſpecies; and I have myſelf obſerved in the latter rhomboids of calcareous ſpar, ſo well mixed with the laminæ of ponderous ſpar, that it is impoſſible to ſeparate them without deſtroying the ſtone. It was among the veins of ponderous ſpar which are found on the road from Portes to Alais, that I ſaw this mixture.

SPECIES II.

Ponderous Spar and Serpentine.

Mr. Kirwan defcribes a fpecies of ferpentine with fpots of barytes.

SPECIES III.

Ponderous Spar and Fluor Spar.

The ponderous fpar of Auvergne is mixed with fluor fpar: I have many fpecimens of this.

SPECIES IV.

Ponderous Spar and Indurated Clay.

This is the Kros-ftein of the Germans. The clay which forms the ground is grey, and includes a ponderous fpar of a white colour, which is difpofed in this clay in the form of veins, that might be taken at firft fight for vermiculites, or, in general, for the remains of fome organized fubftances. This ftone is found at Bochnia in Poland.

SPECIES V.

Ponderous Spar and Quartz.

I have in my collection feveral fpecimens, in which

which the ponderous ſpar is diſpoſed in ſtars upon a matrix of the nature of ſilex.

SPECIES VI.

Ponderous Spar and Lava.

The extinct volcanos of the dioceſe of Beziers have afforded me lavas, partly decompoſed, whoſe ſurface exhibits radii of ponderous ſpar, which, at firſt ſight, I took to be zeolite.

GENUS III.

Rocks or Stones formed by the Mixture of Magneſian Stones with other Kinds.

SPECIES I.

Magneſian Stones mixed together.

The ſame rock often exhibits the various known magneſian ſtones in contact with each other. Thus we ſee the aſbeſtos placed beſide the amianthus, the ſerpentine in contact with the aſbeſtos, the ſteatites in contact with talc.

SPECIES II.

Magneſian Stones and Calcareous Stones.

The ſerpentine has been found ſpotted with calcareous ſpar, and gypſum.

SPECIES III.

Magnefian Stones and Aluminous Stones.

Steatites is frequently mixed with clay. Its fibres are found bedded in an argillaceous fubftance. Steatites and ferpentine are fometimes mixed with fchiftus.

SPECIES IV.

Magnefian Stones and Siliceous Stones.

Serpentine is found mixed with veins of quartz, feld fpar, fchorl, &c.

Afbeftos and amianthus are often confounded, and fometimes incorporated in quartz and rock-cryftal.

Mr. De Sauffure has defcribed a compound ftone, of which the quartz is white, and the fteatites green.

At Sterzing in Tyrol, is found a rock formed by fchorl and ferpentine.

In the county of Mansfield in Saxony, a rock has been difcovered, compofed of jafper and afbeftos.

GENUS IV.

Rocks or Stones formed by the Mixture of Aluminous Stones with other Species.

SPECIES I.

Schiſtus and Mica.

This mixture forms ſeveral primitive mountains. The mica is ſometimes in plates of a certain thickneſs, but moſt commonly in ſmall fragments; and the ſtone aſſumes a brilliant argentine appearance, which renders theſe ſtones agreeable to the ſight. In this laſt caſe, the ſtone is nearly white, ſonorous, and ſplits into leaves; whereas it is blackiſh, and leſs hard, when the mica is diſperſed through it in large grains.

Theſe kinds of micaceous ſchiſti do not become ſpontaneouſly decompoſed. They differ eſſentially from the pyritous ſchiſtus, whoſe formation appears to be poſterior to that of the preſent ſpecies.

This micaceous ſchiſtus is a primitive ſtone. It does not include minerals, or at leaſt very rarely; and it is not ſpontaneouſly decompoſed.

SPECIES II.

Schiſtus and Garnet.

The ſchiſtus frequently contains garnets, which riſe in protuberances in its texture, and ſeparate its ſtrata from each other. The garnet is cryſtallized, and one would be diſpoſed to affirm that this ſtone had increaſed, and almoſt vegetated, in the other, which ſerves as its covering. It is probable that the garnet has been enveloped by this paſte of ſchiſtus; or that it was formed while the ſtone was ſtill almoſt in the fluid ſtate.

I found this ſchiſtus filled with garnets in the bed of the river Bramabiou, in the dioceſe of Alais.

SPECIES III.

Schiſtus, Mica, and Quartz mixed in ſmall fragments.

The Germans call this compound ſtone by the name of Gneiſs. It deſerves to be included among the quartzoſe and ſiliceous ſtones; but as it nearly approaches the primitive ſchiſti we have juſt treated of, we ſhall follow the natural method in claſſing it here.

The

The texture of this ſtone varies greatly. It ſometimes forms a rock in which neither ground nor fibres can be diſtinguiſhed; in other ſpecimens it appears to be divided into filaments twiſted in a thouſand manners, and it frequently exhibits a lamellated hard texture.

It is found in large maſſes of a greyiſh green colour, with its ſurface ſhining, and poliſhed like the ſlate; and it appears to be merely a fine-grained granite, the minuteneſs of whoſe parts has ſuffered them to take the foliated form of the ſchiſtus.

Mr. Weigleb has analyſed that of Friburg.

SPECIES IV.

Schiſtus and Schorl.

The mixture of theſe two ſtones is common enough. The ſchorl is ſometimes diſperſed in very minute filaments, which give a blackiſh tinge to the maſs. Its form is often priſmatic; in which caſe the fibres of the ſchiſtus, and the long cryſtals of the ſchorl, form the priſm by their reunion.

A ſchiſtus has been found in the Pyrenean mountains, in which the ſchorl is ſpread from ſpace to ſpace in the form of oblong bodies, and equally diſperſed over the whole maſs.

SPECIES V.

Clay and Quartz.

This conſtitutes the argillaceous grit-ſtone, or the ſtone in which fragments of quartz are united together by an argillaceous gluten.

Several varieties of grit-ſtone may be diſtin guiſhed. It is often found in irregular, coarſe, and compact maſſes, which are made into mill-ſtones, or uſed for paving, &c.

The magnitude of the fragments of quartz renders the ſurface more or leſs rugged; and it is this which renders it proper for certain operations of trituration.

When its grain is finer, it is made into grind-ſtones. It is by virtue of their quartzous principles that grind-ſtones emit ſuch numerous ſparks, when ſtruck with the ſteel, or when they are moved with rapidity againſt any tool of that metal.

Argillaceous grit-ſtone is ſometimes of a ſcaly texture: the Cos Turcica of Wallerius, and the ſtone uſed for ſharpening ſcythes, are of this kind.

Fine grit-ſtone, compoſed of impalpable particles, is known by the name of Tripoli, from the part of Africa whence it firſt came. It is

now

now found in Rouergue, in Britanny, Germany, and elſewhere.

The porous grit-ſtone called Filtering-ſtone, on account of its uſe, is of the ſame nature.

Quartz is ſometimes mixed with mica. Our province contains it in various places.

The mica is likewiſe found mixed,

1. With feld ſpar, according to Ferber and Kirwan.

2. With ſchorl, at Mont hykie in Dalecarlia in Sweden, and at Sterzing in Tyrol.

3. With garnets, at Paternion in Carinthia, and at the Carpathian mountains in Hungary.

4. With garnet and ſchorl, at Greyner.—See Muller.

5. With quartz, feld ſpar, and ſchorl. This compoſition forms one of the moſt common granites.

The mixture of theſe ſtones, varied in the proportion of their principles or elements, forms the numerous variety of granites; and the ſeveral colours likewiſe modify them exceedingly.

GENUS V.

Compound Stones formed by the Mixture and Re-union of Quartzoſe Stones with each other.

SPE-

SPECIES I.

Quartz and Schorl.

The quartz is, in general, white in this ſtone, and the ſchorl of various colours. Some of the paving-ſtones of London are of this ſort, according to Kirwan. The ſchorl is likewiſe found in cryſtals within the quartz.

SPECIES II.

Quartz and Feld Spar.

A ſtone of this nature was brought me from the neighbourhood of Avenes. The mountain from which the ſpecimen was detached, contains about one-third of quartz. The reſt of the rock conſiſts of rhomboidal feld ſpar, of no great firmneſs of texture, and conſtantly exhibiting the rhombus in its fracture.

I poſſeſs a very fine ſpecimen of a ſimilar rock, which was ſent me from Fahlun in Dalecarlia.

SPECIES III.

Grit-ſtone and Garnet.

I have received from the mines of Tallard, near Gap in Dauphiny, grit-ſtones with garnets of one or two lines in diameter interſperſed.

 Theſe

Theſe garnets are diſperſed through the whole maſs, at the diſtance of three or four lines from each other.

SPECIES IV.

Quartz, Feld Spar, and Schorl.

This mixture is common, and forms great part of the granites on our globe.

The proportion of the elements of this rock vary greatly, but the forms of the ſtones which compoſe it are not leſs variable. The ſchorl is frequently cryſtallized in priſms; the feld ſpar almoſt always exhibits rhomboidal laminæ, on breaking the ſtone; the quartz very ſeldom exhibits determinate figures, but it has nevertheleſs been found in ſuperb cryſtals at Alençon and elſewhere.

The colour of theſe ſtones, likewiſe, exhibits an infinity of ſhades. The ſchorl is uſually black; but it is ſometimes found green, and even white, as in ſome granites brought from Spain. The feld ſpar is commonly of an aſhen grey; but it has been obſerved of a fleſh-colour, of a milk-white, of a dull red, &c. The moſt common appearance of the quartz is, that of a fat and vitreous ſubſtance. It is ſometimes black.

SPECIES V.

Fragments of Quartz united by a Siliceous Cement.

We may here claſs the quartzoſe plum-pudding ſtones. The cement which unites theſe pebbles of quartz, which are commonly rounded, is the paſte of petroſilex. Some of theſe pudding-ſtones are ſo compact, and their fracture is ſo uniform, that they are capable of the moſt beautiful poliſh, and produce a very happy effect by the variety of colour of the ſeveral flints connected by the ſame gluten.

SPECIES VI.

Jaſper and Feld Spar.

This rock is known by the name of Porphyry. The jaſper compoſes the ground, and the feld ſpar is interſperſed in ſmall needles, or in flat parallelopipedons.

The colour of porphyry varies prodigiouſly. The feld ſpar, which enters into its compoſition, is either white, or yellowiſh, or red; but the name of the porphyry is always dependent on the colour of the jaſper. The jaſper is ſome-

times green and ſometimes black, and in ſome inſtances red; which eſtabliſhes a great number of varieties.

As this ſtone is ſuſceptible of the moſt beautiful poliſh, it has been employed as an ornament; and our temples, as well as private houſes, are decorated with it.

Mr. Ferber found in Tyrol porphyry in priſmatic columns, reſembling thoſe of baſaltes; a circumſtance which affords a further degree of probability to the opinion of ſuch as have conſidered porphyry to be a volcanic production.

Porphyry is found in Egypt, in Italy, in Germany, in Sweden, in France, &c. Mr. Dorthes has brought, from various mountains in Auvergne, ſpecimens of porphyric baſaltes in tables and in maſſes, containing cryſtals of feld ſpar, well formed, and little altered.

He obſerved that the rocks of Chevenon, an ancient convent of Gramontin, at the diſtance of one league from Artonne in Auvergne, were very beautiful porphyry. Mr. Guettard found it likewiſe in the foreſt of Eſterelle in Provence.

Mr. Dorthes has deſcribed more than twenty varieties of porphyry thrown up in pebbles by the Mediterranean upon our coaſts, whither they

they are brought by the Rhone. In many of theſe are found tranſparent quartz with the priſmatic form, and cryſtallized feld ſpar.

Porphyry fuſes into a black globule, marked with white points.

The ſpecific gravity of red porphyry is 27,651, and that of green 26,760.—Briſſon.

Porphyry ſometimes contains ſchorl. Wallerius has deſcribed it "Porphir rubens, cum ſpatho ſcintillante albo, et baſalto nigro."

SPECIES VII.

Jaſper and Garnet.

This ſtone has been diſcovered in Iceland: the ground is a green jaſper, which includes ferruginous garnets cryſtallized, and of a red colour.

SPECIES VIII.

Jaſper and Calcedony.

The Mountain of Giants, in Bohemia, affords this ſtone. It has likewiſe been found in the Carpathian mountains, near Kaſkau in Hungary. A ſtone has likewiſe been obſerved at Oberſtein, in the Palatinate, compoſed of agate and jaſper.

SPECIES IX.

Jaſper and Quartz.

This compound ſtone, called Saxum Sibericum by Linnæus, has been found in Siberia, and alſo near Stutgard in the Duchy of Wirtemburg.

SPECIES X.

Jaſper, Quartz, and Feld Spar.

This ſtone is found in the environs of Geneva. Its ground is a jaſper, or rather a petroſilex, black, opake, and very hard. This matrix is interſperſed with ſmall rectangular cryſtals of white feld ſpar, and rounded grains of tranſparent quartz. Mr. De Sauſſure, who has deſcribed this ſpecies, places it among the porphyries.

SPECIES XI.

Schorl, Garnet, and Tourmaline.

Mr. Muller has diſcovered in Schneeburg, a mountain of the territory of Sterzing in Tyrol, a rock of this kind, containing large cryſtals of tourmaline, which include ſmall cryſtallized garnets, tranſparent, and of a red colour.

Mr. Ferber affirms that he found between Faiſtritz and Carnowitz in Stiria, detached pieces of green ſchorl, which incloſe large red garnets: he adds, that this ſchorl is ſometimes ſcaly, and of a micaceous texture.

Mr. De Sauſſure has found in the environs of Geneva, ſtones worn round by water, which were compoſed of ſchorl in the maſs, and garnet.

The Mediterranean Sea throws up on our coaſt many varieties of rounded pebbles of porphyry, which have ſchorl for their baſis.

GENUS VI.

Super-compound Stones, or ſuch as reſult from the Mixture and Re-union of ſeveral different Genera.

SPECIES I.

Petroſilex, Alumine, and Calcareous Spar.

This ſtone is found at Schneeburg in Saxony.

SPECIES II.

Clay, Steatites, and Calcareous Spar.

This ſpecies, as well as the two following, are compriſed under the name of Saxa Glanduloſa. The ſteatites, the ſpar, and the other ſubſtances

are difperfed in the matter which forms the ground of this rock.

SPECIES III.

Clay, Zeolite, Schorl, and Calcareous Spar.

SPECIES IV.

Clay, Serpentine, and Calcareous Spar.

SPECIES V.

Serpentine, Mica, and Calcareous Spar.

Mr. Ferber has defcribed this laft fpecies under the name of Polzevera; a denomination fuggefted to him by the place where it is found. See his Letters on Italy.

SPECIES VI.

Serpentine, Schorl, and Calcareous Stone.

This ftone furrounds the veins of the mine of St. Simon and Jude, at Dognafta, in the Bannat of Temefward: it is likewife found in the copper mines of Safka; and at Hoferfchlag, near Schemnitz, in Lower Hungary.

SPECIES VII.

Steatites, Mica, and Garnets.

This ſtone is found at Handol in Jempterland, towards the north of Sweden.—Born. Ind. Foſſ. par. ii.

SPECIES VIII.

Steatites, Mica, and Schorl.

This ſtone was found at Salbury in Weſtmanland, a province of Sweden.—Born. Ind. Foſſ. par. ii.

SPECIES IX.

Garnets, Quartz, Mica, and Serpentine.

This contains a ſmall quantity of pyrites. It is found at Puſterthal in Tyrol.—See Bruckmann.

SPECIES X.

Feld Spar, Quartz, Mica, Steatites.

Several granites are formed by a mixture of this nature. Such are found at Sunneſkog in Sweden, and at Guten Hoffnangſban near Altwoſchitz

woſchitz in Bohemia: it is the *granites ſteatite mixtus* of Born.

SPECIES XI.

Quartz, Mica, and Clay.

This rock is the matrix of the ore of tin at Platte, and at Gotteſgab in Bohemia.

SPECIES XII.

Quartz, Clay, and Steatites.

This is found at Mount St. Godard in Switzerland.

Concerning the Diamond.

The diamond forms an appendix to the hiſtory of ſtones. Its combuſtibility is a character which prevents its being aſſimilated to any known ſpecies.

The diamond was long conſidered as the hardeſt and moſt ponderous of ſtones, as well as the only one which did not cauſe a double refraction; but ſubſequent obſervations have deſtroyed theſe early notions. The adamantine ſpar appears to equal it in hardneſs; the oriental ruby, and the jargon of Ceylon, are more ponderous; and the oriental precious ſtones

ſtones exhibit one refraction only, as does likewiſe the phoſphoric ſpar.

This precious ſtone is found on the coaſt of Coromandel, and principally in the kingdoms of Golconda and Viſapour. The earth which ſerves as its gangue is red, ochreous, and ſoils the fingers.

The general proceſs of exploring the diamond mines or earths, conſiſts in mixing the earth with water, after which the fluid is poured off, and the ſand which remains at the bottom is dried by the ſtrong heat of the ſun.—See the Memoirs of the Comte Marechal.

Other naturaliſts inform us that, when the earths have been waſhed, the reſidue is left to dry, and is ſifted in baſkets made for the purpoſe. The workmen afterwards ſeek for the diamonds with their hands.

Diamonds in their native ſtate are covered with two cruſts; the one earthy, and the other ſparry.—Romé de Liſle.

When lapidaries undertake to work them, they are obliged to find the grain of the ſtone, in order to ſplit or cleave the diamond. If the fracture be not uniform, they call the ſtone a *diamond of nature*. The hardneſs of the diamond is ſuch, that it reſiſts the moſt highly tempered ſteel;

ſteel; which circumſtance renders it neceſſary to attack it by diamond powder.

The manner or form in which diamonds are cut, diſtinguiſhes them into roſe diamonds, and brilliants, or brilliant diamonds. The brilliant diamond is cut into facets on both ſides. The variety of forms given to theſe facets, and their different inclinations with reſpect to each other, multiply the refractions, and contribute to afford thoſe reflections, and ſtreams of pure and vivid light, which characterize the diamond.

The diamond is divided into two kinds; the oriental diamond, and the Brazilian diamond.

The oriental diamond cryſtallizes in octahedrons, and exhibits all the varieties of this primitive form.

The Brazilian diamond cryſtallizes in dodecahedrons. It is neither ſo hard, ſo heavy, ſo perfect, nor ſo valuable, as the oriental diamond.

The colourleſs diamond has a ſpecific gravity which is in proportion to that of water as 35,212 to 10,000. Mr. Briſſon has derived this ſpecific gravity from an experiment on the *Pitt* diamond of the French crown. A cubic foot of this diamond would weigh two hundred and forty-ſix livres, ſeven ounces, five gros, ſixty-nine grains.

The

The diamond is ſometimes coloured green, violet, black, &c. The green are the moſt eſteemed, becauſe they are the moſt ſcarce. The weight of coloured diamonds is more conſiderable than that of the white diamond; becauſe it is augmented by the weight of the colouring principle, which is of a metallic nature.

The brilliancy, hardneſs, and ſcarcity of the diamond have preſerved it in the moſt extravagant degree of eſtimation. A diamond is ſaid to be of a fine water when it preſents no defect or ſpot; and the price is proportioned to its purity.

When a diamond is without fault, its value is eſtimated according to its weight; which is determined or divided into carats, each carat being equivalent to about four grains.

The moſt beautiful diamonds hitherto known are—1. The two in the crown of the king of France; one of which is the Grand Sancy, weighing one hundred and ſix carats; and the other the Pitt, which weighs ſeven gros, twenty-five grains and one ſixteenth. It is fourteen lines long, thirteen and a half broad, and nine and one-third thick. 2. The diamond which at preſent belongs to the Czarina weighs ſeven hundred and ſeventy-nine carats. The Empreſs purchaſed it in 1772 for twelve tons of gold

gold (100,000 florins), and granted a penſion of four thouſand roubles to the ſeller. It is pretended that this fine diamond was one of thoſe which ornamented the eyes of the famous ſtatue Scheringham, which has eight eyes and four heads; and that it was carried off by a French deſerter who had procured himſelf to be appointed as a guard to the temple of Brama. This diamond was at firſt ſold for fifty thouſand livres, afterwards for about four hundred thouſand livres, and was at length purchaſed by the Empreſs of Ruſſia.

The combuſtibility of the diamond is a phenomenon ſufficiently intereſting to induce us to give a faithful extract of the principal experiments which have ſerved to advance our knowledge upon this ſubject.

Boyle obſerved, long ſince, that the diamond, expoſed to a violent fire, emitted acrid vapours.

The emperor Francis the Firſt cauſed crucibles to be expoſed to a reverberatory fire for twenty-four hours, into which veſſels the value of ſix thouſand florins in diamonds and rubies were put. The diamonds diſappeared, but the rubies were not altered. Theſe experiments were repeated with great expence; and it was aſcertained that the diamond loſt its poliſh, ſcaled off, and was diſſipated.

The Great Duke of Tuſcany, in 1694, cauſed experi-

experiments to be made by Mr. Averoni and Targioni, by the mirror of Tſchirnauſen, and it was found that the diamonds diſappeared in a few minutes.

In 1772, theſe experiments were reſumed by the ſkilful chemiſts of Paris—Darcet, the Comte de Laragais, Cadet, Lavoiſier, Mitouard, Macquer, &c. The details of the intereſting experiments made on this ſubject may be ſeen in the volumes of the Academy of Sciences, and the Journaux de Phyſique, of that year. We ſhall ſimply relate the reſults.

1. Meſſrs. Darcet and the Comte de Laraguais proved that the diamond is volatilized in balls of porcelain.

2. Mr. Macquer took notice that the diamond dilated and ſwelled up; and that a blue flame was obſervable on its ſurface during the combuſtion.

3. Meſſrs. Lavoiſier and Cadet proved, that the combuſtion of diamonds in cloſed veſſels ceaſed as ſoon as the oxigene was deſtroyed; and that the diamond did not burn but in proportion to the oxigene preſent, like all other combuſtible ſubſtances. The jewellers, who expoſe their diamonds to very violent fires to render them colourleſs, are careful to wrap them up in ſuch a manner as to ſecure them from the contact of air.

Mr.

Mr. De Sauffure burned a diamond by the blow-pipe: Mr. Lavoifier has proved that, when it is expofed to the burning glafs, a duft arifes which precipitates lime-water.

The diamond is therefore a combuftible fubftance, which burns in the fame manner as other bodies. This ftrict and accurate confequence is deduced from all the experiments which can be imagined to acquire a perfect demonftration.

Within a few years chemifts have difcovered a very fingular ftone, to which the name of Adamantine Spar has been given by Bergmann.

It is black, and fo hard that its powder may be ufed to cut the diamond; from which circumftance it has obtained its name.

It cryftallizes in hexahedral or fix-fided prifms, two of which are large, and four fmall.

Its fpecific gravity is 38,732 with refpect to water, which is affumed at 10,000. See Briffon.—The cubic foot weighs two hundred and feventy-one livres, one ounce, feven gros, fixty-three grains.

The moft violent fire produces only a flight foftening of this fpar, according to the experiments of Mr. Lavoifier.

The analyfis made by Mr. Klaproth of this ftone, has exhibited a peculiar earth, which is fufpected to be likewife one of the principles of precious ftones, &c.

GENE-

GENERAL VIEWS

RESPECTING

THE DECOMPOSITIONS AND CHANGES TO WHICH THE STONY PART OF OUR GLOBE HAS BEEN SUBJECTED.

IF it were permitted to man to follow, during ſeveral ages, the various changes which are produced on the ſurface of our globe by the numerous agents that alter it, we ſhould at this time have been in poſſeſſion of the moſt valuable information reſpecting theſe great phenomena: but thrown, as we are, almoſt by accident, upon a ſmall point of this vaſt theatre of obſervation, we fix our attention for a moment upon operations which have employed the works of nature for ages; and we are unable either to perceive or to foretel the reſults, be-

cauſe ſeveral ages are ſcarcely ſufficient to render the effects or changes perceptible. Nature never ceaſes to exiſt: her activity has been coeval with the exiſtence of matter; her operations are not circumſcribed within limited times; ſhe diſpoſes of whole ages in the arrangement of her combinations; while man can command no more than a few inſtants, and himſelf diſappears at the moment wherein he has proceeded ſo far as to connect a few facts together. Hence, no doubt, it ariſes, that nature is incomprehenſible in ſome of her operations, and inimitable in all thoſe which require a long ſeries of time.

It muſt be allowed that thoſe men who, by the mere efforts of their imagination, have endeavoured to form ideas reſpecting the conſtruction, and the great phenomena, of this globe, have numerous titles to our indulgence. In their proceedings we behold the efforts of genius, tormented with the deſire of acquiring knowledge, and irritated at the proſpect of the ſcanty means which nature has put in its power: and when theſe naturaliſts, ſuch as Mr. De Buffon, have poſſeſſed the power of embelliſhing their hypotheſes with every ornament which imagination and eloquence can furniſh, either as inſtruments of illuſion or entertainment, we ought to conſider ourſelves indebted to them.

For

For our part, we ſhall confine ourſelves to exhibit a few ideas reſpecting the ſucceſſive decompoſitions of our planet, and ſhall endeavour to avoid every departure from obſervation and matter of fact.

The ſlighteſt obſervation ſhews us that living beings are kept up and perpetuated only by ſucceſſive decompoſitions and combinations. A ſlight view of the mineral kingdom exhibits the ſame changes; and our globe, in all its productions, preſents continual modifications, and a circle of activity, which might appear incompatible with the apparent inertia of lithologic products.

In order to arrange our ideas with greater regularity, we may conſider this globe in two different ſtates. We will firſt examine the primitive rock which forms the nodule or central part. This appears to contain no germ of life, includes no remains or part of any living being, and from every circumſtance appears to have been of primitive formation, anterior to the creation of animated or vegetating bodies. We ſhall purſue the various changes which are daily produced by the deſtructive action of ſuch agents as alter or modify this ſubſtance.

We ſhall then proceed to examine what ſtones have been ſucceſſively placed upon this, and

what are the decompoſitions to which theſe ſecondary rocks have been ſubjected.

1. The obſervations of naturaliſts all unite to prove, that the central part of the globe conſiſts of the ſtone known by the name of Granite. The profound excavations which the art of man, or currents of water, have made in the ſurface of our planet, have all uncovered this rock, and have been incapable of penetrating lower: we may therefore conſider this ſubſtance as the nucleus of the globe; and upon this ſubſtance it is that all matters of poſterior formation reſt.

Granite exhibits many varieties in its form, compoſition, and diſpoſition: but it in general conſiſts of an aſſemblage of certain ſiliceous ſtones, ſuch as quartz, ſchorl, feld ſpar, mica, &c.; and the more or leſs conſiderable magnitude of theſe elements of granite, has cauſed it to be divided into coarſe-grained granite, and fine-grained granite.

It appears to me that there is no denying but that theſe rocks owe their arrangement to water: and if we may be permitted to recur, by an effort of the imagination*, to that epocha in which, according

* This is the firſt and the laſt ſuppoſition in which I ſhall indulge myſelf. It is a conjecture however which is indifferent with

according to sacred and profane historians, the water and earth were confounded, and the confused mixture of all principles formed a chaos, we shall see that the laws of gravity inherent in matter must have carried it down, and necessarily produced the arrangement which observation at present exhibits to us. The water, as the least heavy, must have purified itself, and arisen to the surface by a filtration through the other materials: while the earthy principles must have precipitated, and formed a mud, in which all the elements of stones were confounded. In this very natural order of things, the general law of affinities, which continually tends to bring together all analogous parts, must have exerted itself with its whole activity upon the principles of this almost fluid paste; and the result must have been a number of bodies of a more definite kind, in crystals more or less regular: and from this muddy substance, in which the principles of the stones were confounded that compose the granite, a rock must have been produced, containing the elementary stones all

with respect to the basis of the subject itself; since it relates only to an hypothesis respecting the manner in which a rock might be formed that at present exists, and whose decompositions alone can form the subject of our observations.

in

in poſſeſſion of their diſtinct forms and characters. In this manner it is that we obſerve ſalts of very different kinds develope themſelves in waters which hold them in ſolution; and in this manner it ſtill happens that cryſtals of ſpar and gypſum are formed in clays which contain their component parts.

It may eaſily be conceived that the laws of gravitation muſt have influenced the arrangement and diſpoſition of the products. The moſt groſs and heavy bodies muſt have fallen, and the lighteſt and moſt attenuated ſubſtances muſt have arranged themſelves on the ſurface of the foregoing: and this it is which conſtitutes the primitive ſchiſti, the gneis, the rocks of mica, &c. which commonly repoſe upon maſſes of coarſe-grained granite.

The diſpoſition of the fine-grained granite in ſtrata or beds, appears to me to depend on this poſition, and the fineneſs or tenuity of its parts. Being placed in immediate contact with water, this fluid muſt naturally have influenced the arrangement which it preſents to us; and the elements of this rock being ſubjected to the effect of waves, and the action of currents, muſt have formed ſtrata.

The rocks of granite being once eſtabliſhed as the nucleus of our globe, we may, from the analyſis

analyſis of its conſtituent principles, and by attending to the action of the various agents capable of altering it, follow the degradations to which it has been ſubjected, ſtep by ſtep.

Water is the principal agent whoſe effects we ſhall examine.

This fluid, collected in the cavity of the ocean, is carried by the winds to the tops of the moſt elevated mountains, where it is precipitated in rain, and forms torrents, which return with various degrees of rapidity into the common reſervoir.

This uninterrupted motion and fall muſt gradually attenuate and wear away the hardeſt rocks, and carry their pulverulent parts to diſtances more or leſs conſiderable. The action of the air, and the varying temperatures of the atmoſphere, facilitate the attenuation and the deſtruction of theſe rocks. Heat dries their ſurface, and renders it more acceſſible and more penetrable to the water which ſucceeds; cold divides them, by freezing the water which has entered into their texture; the air itſelf affords the carbonic acid, which attacks the lime-ſtone, and cauſes it to effloreſce; the oxigene unites to the iron, and calcines it: inſomuch that this concurrence of cauſes favours the diſunion of principles; and conſequently the action of water, which clears the ſurface, carries away the

products of decompoſition, and makes preparation for a ſucceeding proceſs of the ſame nature.

The firſt effect of the rain is therefore to depreſs the mountains. But the ſtones which compoſe them muſt reſiſt in proportion to their hardneſs; and we ought not to be ſurpriſed when we obſerve peaks which have braved the deſtructive action of time, and ſtill remain to atteſt the primitive level of the mountains which have diſappeared. The primitive rocks, alike inacceſſible to the injury of ages as to the animated beings which cover leſs elevated mountains with their remains, may be conſidered as the ſource or origin of rivers and ſtreams. The water which falls on their ſummits, flows down in torrents by their lateral ſurfaces. In its courſe it wears away the ſoil upon which it inceſſantly acts. It hollows out a bed, of a depth proportioned to the rapidity of its courſe, the quantity of its waters, and the hardneſs of the rock over which it flows; at the ſame time that it carries along with it portions and fragments of ſuch ſtones as it looſens in its courſe.

Theſe ſtones, rolled along by the water, muſt ſtrike together, and break off their projecting angles: a proceſs that muſt quickly have afforded thoſe rounded flints which form the pebbles of rivers.

rivers. Theſe pebbles are found to diminiſh in ſize, in proportion to the diſtance from the mountain which affords them; and it is to this cauſe that Mr. Dorthes has referred the diſproportionate magnitude of the pebbles which form our ancient worn ſtones, when compared with thoſe of modern date: for the ſea extending itſelf formerly much more inland, in the direction of the Rhone, the ſtones which it received from the rivers, and threw back again upon the ſhores, had not run through ſo long a ſpace in their beds as thoſe which they at preſent paſs over. Thus it is that the remains of the Alps, carried along by the Rhone, have ſucceſſively covered the vaſt interval compriſed between the mountains of Dauphiny and Vivarais; and are carried into our ſeas, which depoſit them in ſmall pebbles on the ſhore.

The pulverulent remains of mountains, or the powder which reſults from the rounding of theſe flints, are carried along with greater facility than the flints themſelves: they float for a long time in the water, whoſe tranſparence they impair; and when theſe ſame waters are leſs agitated, and their courſe becomes ſlackened, they are depoſited in a fine and light paſte, forming beds more or leſs thick, and of the ſame nature as that of the rocks to which they owe their origin. Theſe ſtrata gradually be-

come

come drier by the agglutination of their principles; they become conſiſtent, acquire hardneſs, and form ſiliceous clays, ſilex, petroſilex, and all the numerous claſs of pebbles which are found diſperſed in ſtrata, or in banks, in the ancient beds of rivers.

Mr. Pallas has obſerved the tranſition of clay to the ſtate of ſilex in the brook of Sunghir, near Wolodimir. Mr. J. W. Baumer has likewiſe obſerved it in Upper Heſſe.

The mud is much more frequently depoſited in the interſtices left between the rounded flints themſelves, which intervals it fills, and there forms a true cement that becomes hard, and conſtitutes the compound ſtones known by the name of pudding-ſtones and grit-ſtones; for theſe two kinds of ſtones do not appear to me to differ but in the coarſeneſs of the grain which forms them, and the cement which connects them together.

We ſometimes obſerve the granite ſpontaneouſly decompoſed. The texture of the ſtones which form it has been deſtroyed; the principles or component parts are diſunited and ſeparated, and they are gradually carried away by the waters. I have obſerved near Mende, towards Caſtelnouvel, the moſt beautiful kaolin on the ſurface of a granite, in a ſtate of decompoſition; and

and this ſame rock is decompoſed in ſeveral other parts of our province. It appeared to me that the feld ſpar was particularly ſubject to be altered the firſt.

Moſt ſiliceous ſtones, formed by the depoſition of fluviatile waters, and hardened by the lapſe of time, are eaſily ſubjected to a ſecond decompoſition. Iron is the principal agent of theſe ſecondary alterations; and its calcination, determined by air or water, produces a diſunion of principles. Nature may be obſerved in this proceſs, by an attentive examination of ſuch alterations as gun flints, variolites, porphyries, jaſpers, and the like, are ſubjected to.

The decompoſition of flints, calcedonies, agates, and generally all ſtones of this kind which poſſeſs a certain degree of tranſparence, appears to me to be referable to the volatilization of the water, which forms one of their principles, and is the cauſe of their tranſparency.

Theſe ſtones may be conſidered as commencements of cryſtallization; and, when the water is diſſipated, they effloreſce after the manner of certain neutral ſalts. Hence it ariſes that the decompoſition is announced by opacity, a white colour, loſs of conſiſtence and hardneſs; and terminates by forming a very attenuated powder, ſometimes of extreme whiteneſs. It is this

decompoſition, more particularly, which forms clays.

There are flints whoſe alterations form effervefcent marles. Theſe do not appear to me to be of the nature of primitive rocks: they have the ſame origin as the calcareous ſtones, from which they differ only in conſequence of a very conſiderable proportion of clay. The ſtones which we ſo abundantly find of this nature around us, among calcareous decompoſitions, may be conſidered as of this kind.

Water filtrating through mountains of primitive rock, frequently carries along with it very minutely divided particles of quartz; and proceeds to form, by depoſition, ſtalactites, agates, rock cryſtal, &c.

Theſe quartzoſe ſtalactites, differently coloured, are of a formation conſiderably analogous to that of calcareous alabaſters; and we perceive no other difference between them than that of their conſtituent parts.

II. Thus far we have exhibited, in a few words, the principal changes, and various modifications, to which the primitive rocks have been ſubjected. We have not yet obſerved either germination or life; and the metals, ſulphur, and bitumens, have not hitherto preſented themſelves to our obſervation. Their formation

tion appears to be poſterior to the exiſtence of this primitive globe; and the alterations and decompoſitions which now remain to be enquired into, appear to be produced by the claſs of living or organized beings.

On the one hand, we behold the numerous claſs of ſhell animals, which cauſe the ſtony maſs of our globe to increaſe by their remains. The ſpoils of theſe creatures, long agitated and driven about by the waves, and more or leſs altered by colliſion, form thoſe ſtrata and banks of lime-ſtone, in which we very often perceive impreſſions of thoſe ſhells to which they owe their origin.

On the other hand, we obſerve a numerous quantity of vegetables that grow and periſh in the ſea; and theſe plants likewiſe, depoſited and heaped together by the currents, form ſtrata, which are decompoſed, loſe their organization, and leave all the principles of the vegetable confounded with the earthy principle. It is to this ſource that the origin of pit-coal, and ſecondary ſchiſtus, is uſually attributed; and this theory is eſtabliſhed on the exiſtence of the texture of decompoſed vegetables very uſually ſeen in ſchiſti and coal, and likewiſe on the preſence of ſhells and fiſh in moſt of theſe products.

It

It appears to me that the formation of pyrites ought to be attributed to the decompoſition of vegetables: it exiſts in greater or leſs abundance in all ſchiſti and coal. I have found a wooden ſhovel buried in the depoſitions of the river De Ceze, converted into jet and pyrites. The decompoſition of animal ſubſtances may be added to this cauſe: and it appears to me to be a confirmation of theſe ideas, that we find many ſhells paſſed to the ſtate of pyrites.

Not only the marine vegetables form conſiderable ſtrata by their decompoſition; but the remains of thoſe which grow on the ſurface of the globe ought to be conſidered among the cauſes or agents which concur in producing changes upon that ſurface.

We ſhall ſeparately conſider how much is owing to each of theſe cauſes; and ſhall follow the effects of each, as if that cauſe alone were employed in modifying and altering our planet.

1. The calcareous mountains are conſtantly placed upon the ſurface of the primitive mountains; and though a few ſolitary obſervations preſent a contrary order, we ought to conſider this inverſion and derangement as produced by ſhocks which have changed the primitive diſpoſition. I muſt obſerve alſo that the diſorder is ſometimes merely apparent; and that

ſome naturaliſts of little information have deſcribed calcareous mountains as inclining beneath the granite, becauſe this laſt pierces, as it were, through the envelope, riſes to a greater height, and leaves at its feet, almoſt beneath it, the calcareous remains depoſited at its baſe.

Sometimes even the lime-ſtone fills to a very great depth the crevices or clefts formed in the granite. I have ſeen in Gevaudan, towards Florac, a profound cavity in the granite filled with calcareous ſtone. This vein is known to poſſeſs a depth of more than one hundred and fifty toiſes, with a diameter of about two or three.

It likewiſe happens frequently enough that ſuch waters as are loaded with the remains of the primitive granite, heap them together, and form ſecondary granites, which may exiſt above the calcareous ſtone.

Theſe calcareous mountains are decompoſed by the combined action of air and water; and the product of their decompoſition ſometimes forms chalk or marle.

The lightneſs of this earth renders it eaſy to be tranſported by water; and this fluid, which does not poſſeſs the property of holding it in ſolution, ſoon depoſits it in the form of gurhs, alabaſters, ſtalactites, &c. Spars owe their formation

mation to no other cauſe. Their cryſtallization is poſterior to the origin of calcareous mountains.

Waters wear down and carry away calcareous mountains with greater eaſe than the primitive mountains: their remains being very light, are rolled along, and more or leſs worn. The fragments of theſe rocks are ſometimes connected by a gluten or cement of the ſame nature; from which proceſs calcareous grit and breccias ariſe. Theſe calcareous remains formerly depoſited themſelves upon the quartzoſe ſand; and the union of primitive matter, and ſecondary products, gives riſe to a rock of a mixed nature, which is common in our province.

2. The mountains of ſecondary ſchiſtus frequently exhibit to us a pure mixture of earthy principles, without the ſmalleſt veſtige of bitumen. Theſe rocks afford, by analyſis, ſilex, alumine, magneſia, lime in the ſtate of carbonate, and iron; principles which are more or leſs united, and conſequently acceſſible in various degrees to the action of ſuch agents as deſtroy the rocks hitherto treated of.

Theſe ſame principles, when diſunited, and carried away by waters, give riſe to a great part of the ſtones which we have compriſed in the magneſian genus. The ſame elements, worn down

down by the waters, and depoſited under circumſtances proper to facilitate cryſtallization, form the ſchorls, tourmaline, garnets, &c.

We do not pretend by this to exclude and abſolutely reject the ſyſtem of ſuch naturaliſts as attribute the formation of magneſian ſtones to the decompoſition of the primitive rocks. But we think that this formation cannot be objected to for ſeveral of them, more eſpecially ſuch as contain magneſia in the greateſt abundance.

It frequently happens that the ſecondary ſchiſti are interſperſed with pyrites; and, in this caſe, the ſimple contact of air and water facilitates their decompoſition. Sulphuric acid is thus formed, which combines with the various conſtituent principles of the ſtone; whence reſult the ſulphates of iron, of magneſia, of alumine, and of lime, which effloreſce at the ſurface, and remain confounded together. Schiſti of this nature are wrought in moſt places where alum works have been eſtabliſhed; and the moſt laborious part of this undertaking conſiſts in ſeparating the ſulphates of iron, of lime, and of magneſia from each other, which are mixed together. Sometimes the magneſia is ſo abundant that its ſulphate predominates: I have ſeen mountains of ſchiſtus of this nature. The ſulphate of lime being very ſparingly ſoluble in

water, is carried away by that liquid, and depoſited to form gypſum; while the other more ſoluble ſalts remaining ſuſpended, form vitriolic mineral waters.

The pyritous ſchiſti are frequently impregnated with bitumen, and the proportions conſtitute the various qualities of pit-coal.

It appears to me that we may lay it down as an inconteſtable principle, that the pyrites is abundant in proportion as the bituminous principle is more ſcarce. Hence it ariſes, that coals of a bad quality are the moſt ſulphureous, and deſtroy metallic veſſels by converting them into pyrites. The focus of volcanos appears to be formed by a ſchiſtus of this nature; and in the analyſes of the ſtony matters which are ejected we find the ſame principles as thoſe which conſtitute this ſchiſtus. We ought not therefore to be much ſurpriſed at finding ſchorls among volcanic products; and ſtill leſs at obſerving that ſubterranean fires throw ſulphuric ſalts, ſulphur, and other analogous products out of the entrails of the earth.

3. The remains of terreſtrial vegetables exhibit a mixture of primitive earths more or leſs coloured by iron: we may therefore conſider theſe as a matrix in which the ſeeds of all ſtony combinations are diſperſed. The earthy principles

ciples aſſort themſelves according to the laws of their affinities; and form cryſtals of ſpar, of plaſter, and even the rock cryſtals, according to all appearance: for we find ochreous earths in which theſe cryſtals are abundantly diſperſed; we ſee them formed almoſt under our eyes. I have frequently obſerved indurated ochres full of theſe cryſtals terminating in two pyramids.

The ochreous earths appear to me to deſerve the greateſt attention of naturaliſts. They conſtitute one of the moſt fertile means of action which nature employs; and it is even in earths nearly ſimilar to theſe that ſhe elaborates the diamond, in the kingdoms of Golconda and Viſapour. If it were allowable to indulge in a fiction purely poetical, we might affirm that the element of fire, ſo far from being loſt by the diſperſion of the combuſtible principles of vegetables, becomes purified to form this precious ſtone ſo eminently combuſtible; that nature has been deſirous of proving that the terms Deſtruction and Death are relative only to the imperfection of our ſenſes; and that ſhe is never more fruitful than when we ſuppoſe her to be at the moment of extinction.

The ſpoils of animals, which live on the ſurface of the globe, are entitled to ſome conſideration among the number of cauſes which we

aſſign to explain the various changes our planet is ſubjected to. We find bones in a ſtate of conſiderable preſervation in certain places; we can even frequently enough diſtinguiſh the ſpecies of the animals to which they have belonged. From indications of this ſort it is that ſome writers have endeavoured to explain the diſappearance of certain ſpecies; and to draw concluſions from thence, either that our planet is perceptibly cooled, or that a ſenſible change has taken place in the poſition of the axis of the earth. The phoſphoric ſalts and phoſphorus which have been found, in our time, in combination with lead, iron, &c. prove that, in proportion as the principles are diſengaged by animal decompoſition, they combine with other bodies, and form the nitric acid, the alkalis, and in general all the numerous kinds of nitrous ſalts.

PART III.

CONCERNING METALLIC SUBSTANCES.

INTRODUCTION.

METALLIC ſubſtances are diſtinguiſhed from all the other productions of our globe, by an abſolute opacity, a much greater ſpecific gravity than that of any other ſubſtance, and a degree of brilliancy peculiar to bodies of this claſs.

The multiplicity of uſes to which metals are applied in the arts, and in medicine, as well as the place which they occupy in the natural hiſtory of our planet, render the ſtudy of them both intereſting and neceſſary.

1. One of the diſtinctive characters of metals is their opacity. The moſt opake ſtone, divided into very thin laminæ, becomes tranſparent; whereas the thinneſt plate of metal preſerves

the ſame opacity as the maſs itſelf*. This truly characteriſtic property has induced artiſts to employ metals to reflect the images of objects. A thin covering of tin and mercury fixed on the ſurface of a glaſs, forms a mirror or looking-glaſs; and well-poliſhed ſteel conſtitutes the mirrors of teleſcopes†. The hardneſs of a metal contributes ſingularly to facilitate the reflection of objects, as it renders it capable of taking a very fine poliſh: but its colour muſt neceſſarily concur to render it perfect; for theſe tinges

* Gold excepted; which, when beaten into leaf of about the two hundred and eighty thouſandth part of an inch in thickneſs, tranſmits light of a beautiful green colour. It is highly probable that other metals would become tranſparent if they could be mechanically divided, or beaten out into laminæ of ſufficient thinneſs, or if artiſts had ſufficient motives to attempt it.

See Newton on Light and Colours, for the proofs on which he grounds his general inference—that all bodies are tranſparent when ſufficiently divided. T.

† I do not find that ſteel has ever been in general uſe for reflecting teleſcopes, though it has doubtleſs been tried among the many experiments made for the improvement of theſe inſtruments. A kind of bell-metal, conſiſting of one-third tin, and two-thirds copper, is commonly employed for this purpoſe: the addition of about a fiftieth part of arſenic ſingularly contributes to the cloſeneſs of its grain. On this ſubject conſult the Treatiſe of Mr. Edwards, annexed to the Nautical Almanac for 1787. T.

cauſe

cauſe it to abſorb a greater or leſs quantity of the rays. The great defect of metallic mirrors is, that their ſurface becomes tarniſhed by the inevitable alteration which the action of the air and moiſture muſt produce.

2. The relative weight is likewiſe a character by which we may diſtinguiſh a metallic ſubſtance. A cubic foot (French) of marble weighs 190 pounds (livres); a cubic foot of tin weighs 510; and a cubic foot of gold 1348.

The metals, in general, likewiſe poſſeſs the facility of being extended and flattened when ſtruck, or ſubjected to a ſtrong and gradual preſſure: this property is known by the name of Ductility. All the metals do not poſſeſs this quality; but thoſe which poſſeſs the metallic qualities moſt eminently, exhibit this likewiſe. We may diſtinguiſh three ſtates of ductility relative to the manner in which it is modified by various known proceſſes. 1. Ductility under the hammer. 2. Ductility through the plate of the wire-drawer. 3. Ductility between the laminating rollers.

Metals ductile under the hammer preſent themſelves in the following order: Gold, Silver, Copper, Iron, Tin, and Lead.

Metals ductile through the wire-drawer's plate

 form

form the following ſeries: Gold, Iron, Copper, Silver, Tin, and Lead.—As, in the operation of wire-drawing, the metal is ſtrongly drawn, to cauſe it to paſs through holes of various diameters, and to reduce it into threads, the metals do not reſiſt this prodigious extenſion but in proportion to their greater or leſs tenacity. Mr. De Fourcroy has therefore diſtinguiſhed this ductility from the foregoing, by attributing it merely to the tenacity of the metals.

There are ſome metals which are not ductile either under the hammer or through the wire-drawer's plate, but become very conſiderably ſo when an equal and gradual preſſure is applied. Zinc is of this nature. Mr. Sage has reduced it into very thin and very flexible leaves, by paſſing it between the laminating cylinders.

Heat aſſiſts the ductility of all metals, by ſeparating their integrant parts, and forming ſpaces or interſtices which permit the compreſſed molecules to flatten and extend themſelves. This circumſtance has induced artiſts to avail themſelves of the aſſiſtance of heat in the working of metals. Without this precaution they would either become hard, or crack; becauſe the particles, being too near each other, would be no longer capable of giving way under the hammer.

The

The ductility of metals permits us to faſhion them as we think fit; and it is upon this admirable property that almoſt all the arts are founded which relate to the working of metals. Without this property, metallic bodies would conſiſt either of ſhapeleſs maſſes, or large pieces of ſuch figures as caſting might produce. But we ſhould be deprived of the number of various objects which the arts have ſucceſſively afforded to ſupply our wants or luxuries.

Nature very ſeldom preſents us with metals poſſeſſed of the degrees of perfection here enumerated. She has concealed them in the bowels of the earth, combined with various ſubſtances; which, by maſking or changing the metallic properties, have left to the induſtry of man the laborious taſk of extracting them, clearing them of their original combinations, and giving them the valuable qualities which are peculiar to metals. The metals, thus buried and concealed, form ores. Theſe ores uſually exiſt in clefts or crevices of rocks, which are diſtinguiſhed by the name of Veins. Theſe veins are more or leſs inclined to the horizon; and the degrees of inclination have cauſed them to be diſtinguiſhed by the names of direct, oblique, inclined, or level veins, according to the angle they make with the horizon. The part of the rock

rock which refts upon the fuperior part of the vein, is called the Roof; and that part upon which the vein itfelf refts, is called the Bed of the vein. Thefe veins are of various breadths, and are accordingly diftinguifhed by the names of Slips or Veins.

They poffefs a greater or lefs degree of continuity, according to which they are diftinguifhed by the names of continued or broken veins; and when the ore is found in fpherical parts or maffes, from fpace to fpace, thefe maffes are called Bellies or Stock-works. A vein which does not penetrate to a confiderable depth in the earth, is called by us *Coureur de Gazon.*

The characters from which mineralogifts pretend to affert the exiftence of an ore in the bowels of the earth, are all equivocal and fufpicious. The favage afpect of a mountain, the nature of the plants which grow upon it, the exhalations which arife from the earth, all afford characters too doubtful for a reafonable man to rifk his fortune upon fuch indications alone. The dipping wand, or divining rod, is the fruit of fuperftition and ignorance: and the ridicule which has been fucceffively thrown upon this clafs of impoftors, has diminifhed their number; at the fame time that the numerous dupes of this

this clafs of men have rendered their fucceffors more prudent.

The nature of the ftones which compofe a mountain is capable of furnifhing fome indications. We know, for example, that ores are feldom found in granite, and the other primitive mountains; we know likewife that mountains of too modern a formation contain them very rarely; and we find them only in fecondary mountains, in which the fchiftus and ancient calcareous ftone are void of all impreffions of fhells.

The prefence of ponderous fpar, forming a ftratum or vein at the furface of the earth, has been confidered by many mineralogifts as a very good indication. It appears to me even that this ftone is the fame which Becher has fpoken of in his works, under the name of Vitrifiable Earth, which he confidered as a principle of metals; and that it has been very improperly taken for quartz by his readers.

The vitrifiable ftone of Becher—"lapidis fpecies quæ in igne fluit, et fluens vitrum exhibet,"—and elfewhere, "tranfparens enim nonnihil eft, albus, et quafi argenteis foliis interfperfus, ad ignem facilè liquabilis,"—was confidered by him as a certain indication of the prefence of ores, as appears by the following paffage:

"Sine

"Sine quo lapide, nulla minera bona eſt, nec fertilitatem promittit; adeò enim iſte lapis mineris neceſſarius eſt, ut vel nudè, et ſine ullo metallo, in montibus exiſtens, infallibile ſignum futuri metalli ſit; quod, hoc ſigno freti, non ſine magnis interdum ſumptibus, quærunt minerarum indagatores; hanc ergo ſive terram ſive lapidem, non ſine pregnantibus cauſis, pro principio primo omnium metallorum, minerarum, et lapidum ac gemmarum, ſtatuimus et agnoſcimus; certis freti experimentis, ut in ſequentibus demonſtrabimus, quibus evincere poſſumus præfatam terram actu in metallis et mineralibus omnibus, nec non lapidibus et gemmis, exiſtere, eorumque mixtum ut baſim et fundamentum ingredi; unde ea hypoſtaſin ſuam, oppoſitatem, diaphaneitatem, et fluxum nanciſcuntur..... Hæc ergo terra non modò cum preſens adeſt infallibile ſignum affuturi metalli eſt, ſed et abſens idem ſignum exiſtit, defuturi nempè metalli..... defectus hujus terræ proxima et frequentiſſima cauſa ſterilium minerarum exiſtit.... lapis de quo egimus, non modo ut matrix ſed ut ingrediens et principium."

When we poſſeſs indications of the exiſtence of an ore in any place, we may uſe the borer, to confirm or deſtroy theſe ſuſpicions, at a ſmall expence.

It

It frequently happens that the veins are naked or uncovered: the mixture of ſtones and metals forms a kind of cement which reſiſts the deſtructive action of time longer than the reſt of the mountain; and as theſe parts of rocks, connected by a metallic cement, preſent a ſtronger reſiſtance to the action of waters, which inceſſantly corrode and diminiſh mountains, and carry away their parts into the ſea, we frequently obſerve the veins projecting on the ſides of mountains incruſted with ſome ſlight metallic impreſſion altered by the lapſe of time.

Before we proceed to treat of metallic works in the large way, it will be proper to explain the methods of judging of the nature and value of an ore, in order that the members of ſociety may not raſhly hazard their fortunes. The nature of an ore is judged from inſpection. A ſlight acquaintance with this ſubject is ſufficient to enable the obſerver to form an immediate judgment of the nature of an ore. The blow-pipe is an inſtrument by the aſſiſtance of which we may in a ſhort ſpace of time become acquainted likewiſe with the ſpecies of the ore. This knowledge forms the docimaſtic art, or docimaſia. In order to make the aſſay of an ore, in general (for all ores do not require the ſame proceſs, as we ſhall hereafter obſerve), ſmall pieces

of

of the mineral are examined. These are cleared from foreign and stony substances as much as possible. The pure mineral is then pounded, and a certain quantity weighed, which is torrefied in a vessel larger and less deep than a common crucible. By this means the sulphur or the arsenic in combination with the metal are dissipated; and by the loss of weight resulting from the calcination, a judgment is formed of the proportion of foreign volatile matter it contained.

This first operation shews the proportion and quantity of sulphur and arsenic which may be mixed with the metal. The sulphureous smell may easily be distinguished from the smell of garlic, which characterizes arsenic. These foreign substances mixed with the metal are called Mineralizers.

In order to obtain an accurate judgment of the weight of the mineralizer, the augmentation in weight which the metal has undergone in passing from its metallic state to that of oxide or calx, must be added to the loss occasioned by the calcination.

Two hundred grains of this roasted ore are then to be taken, and mixed with fluxes capable of fusing and reducing it. In this operation a crucible is made use of; and a sufficient degree

of heat being applied, the metal is precipitated to the bottom of the crucible in a button, whoſe weight indicates the quantity of metal contained in the ore.

Theſe fluxes muſt be varied according to the nature of the ores under examination. It is neceſſary that they ſhould all contain the coaly principle, to diſengage the oxigene with which theſe metals are impregnated by the calcination. But the nature of the flux muſt be varied according to the fuſibility of the metal. The three following will anſwer all theſe purpoſes.

1. The fuſible material called black flux is made with two parts of tartar, and one part of nitre, melted together. The coaly and alkaline reſidue is uſed to reduce the ores of lead, copper, antimony, &c.

2. Two hundred grains of calcined borax, one hundred grains of nitre, twenty grains of ſlacked lime, and one hundred grains of the ore intended to be aſſayed, form the flux of Scopoli, of which I have found the advantage in the aſſay of iron ores.

The vitreous flux of Mr. De Morveau, made with eight parts of pounded glaſs, one of borax, and half a part of powder of charcoal, may be employed for the ſame purpoſe.

3. Arſe-

3. Arſenic and nitre, in equal parts, form likewiſe a very active flux.

The neutral arſenical ſalt has been uſed with ſucceſs to fuſe platina.

As ſoon as the exiſtence of a mine, and its nature and riches, are aſcertained, it is in the next place neceſſary to be aſſured of a ſufficient abundance and continuity of water to anſwer the purpoſes of the works. It is likewiſe neceſſary to be aſſured of poſſeſſing a ſufficient quantity of wood or charcoal; and, more eſpecially, a good director muſt be procured: for, in my opinion, a poor mine well managed is preferable to a rich one ill conducted.

Theſe preliminary circumſtances being accompliſhed, the moſt ſimple and leaſt expenſive proceſſes muſt be employed in extracting the mineral from the bowels of the earth. For this purpoſe, ſhafts or galleries muſt be dug, according to the poſition of the vein, and the nature of its ſituation.

When it is practicable to arrive at the ſide of the vein, and at a certain depth, by a horizontal gallery, the works become more ſimple and economical; the ſame opening ſerving to draw off the waters, and extract the ore. Galleries are then to be carried on to the right and left; and ſhafts

ſhafts ſunk, which communicate with the open air, as likewiſe others carried down into the vein. Galleries are likewiſe conſtructed, one above the other, and the communication of the works kept up by ladders. When the ſoil is friable, and defective in ſolidity, care muſt be taken to ſupport it with timbers of ſufficient ſtrength, to prevent its falling in.

Pickaxes, wedges, and levers are uſed to detach the ore, when the rock is ſoft; but it is moſt commonly neceſſary to employ gunpowder, and to form mines.

Want of air, and the abundance of water, are almoſt always noxious, and derange mine-works. The water is carried off by fire-engines, windmill pumps, and other ſuitable apparatus.

Currents of air are produced by eſtabliſhing communications with the galleries by horizontal apertures. Furnaces erected on the ſide of a ſhaft, to which a long tube is adapted at one end, communicating with the aſh-hole, and at the other plunging into the ſhaft to draw up the air, or ventilators placed in the ſame ſituation, anſwer a ſimilar purpoſe. The foul air is deſtroyed by rendering a lixivium of aſhes cauſtic; and ſprinkling quick-lime about the mine likewiſe produces the ſame effect.

 A pru-

A prudent company ought to extract the largest possible quantity of ore, before they determine upon constructing the necessary works for the subsequent processes. We cannot see into the bowels of the earth. Appearances are often deceitful; and we have seen companies either ruined or discouraged, because they had employed immense sums to construct the necessary furnaces to work an ore whose existence was doubtful. When the proceedings, in an undertaking of this kind, are carried on with proper precaution, and no more expence is entered into than what the ore extracted, and of a known value, is capable of representing, the probable losses are very slight, even in the poorest mine.

The works ought to be varied according to the nature and state of the mineral. It is found in three states—1. In the form of a native metal: in this case, nothing more is necessary than to extract it out of the mine, to clear it of the extraneous substances, and to fuse it. 2. In the form of calx or oxide; and in this state it is sufficient if it be sorted and fused. 3. Combined with sulphur or arsenic, in which case it must be made to undergo some other operations.

Although, in this last case, the works, subse-

quent to the extraction, vary according to the nature of the ore, there are neverthelefs certain general operations to which every kind of ore is fubjected, which we fhall here fpeak of.

The metal is always mixed with ftony fubftances, which are called the Gangue. The firft bufinefs muft therefore be to clear the metal of this foreign fubftance. For this purpofe, when the ore is extracted, children are employed who examine it, and feparate the pure ore or rich mineral from that which is mixed with the gangue. As in this fecond quality the ftone is mixed with the ore, the whole is pulverized by means of a ftamping mill, confifting of peftles of wood, fhod with iron, and armed with cocks, which are raifed by levers proceeding from the axis of a wheel that conftantly turns. The mineral is by this means crufhed and pulverized; and a ftream of water which is made to pafs over it, carries away both the metallic and ftony particles; the former being depofited in the firft veffels through which the water is made to circulate, while the latter or ftony part is carried to a greater diftance on account of its lightnefs.

This pulverized ore is called Sclich; and, in order to feparate all the earthy parts, it is wafhed upon tables flightly inclined, over which a con-

ſtant ſtream of water is made to flow. The ſclich is agitated with brooms; the water carries away all the fragments of ſtone, and leaves the pure ore upon the table.

The calcination of the mineral ſucceeds the waſhing. In this operation the mineralizer is carried off. Fire is always the agent made uſe of. Sometimes the pounded mineral is diſpoſed in piles upon heaps of wood, which, being ſet on fire, heat the ore ſtrongly, and drive off the mineralizer. This calcination poſſeſſes the double advantage of diſpoſing the metal for fuſion, as well as clearing it of the mineralizing ſubſtance. When the ore is more friable, it is ſpread out in a reverberatory furnace; and the flame which reverberates upon it deprives it of its mineralizer, at the ſame time that it partly fuſes it.

Mr. Exchaquet has propoſed to deſtroy the ſulphur by nitre. This proceſs is excellent for copper ores. The quantity of nitre varies according to the quantity of ſulphur; but there is no danger of adding too much. In this operation the mixture is thrown into an ignited crucible, and kept at a moderate heat for ſome minutes.

The fuſion is effected in furnaces, excited by a current of air, kept up by means of large bellows, or a machine called a *trompe*.

The

The trompe, or blowing machine *, is formed of a hollow tree which refts upon a cafk whofe lower head is knocked out, and the open part of the cafk itfelf plunged to a certain depth under water. A current of water is made to fall through this wooden trunk upon a ftone which is erected in the middle of the cafk. The air becomes difengaged, and is obliged to pafs out at a collateral aperture in the cafk, by means of a tube which carries it to the lower part of the furnace. This air is afforded—1. By that air which the water carries along with it. 2. By a current which paffes through apertures made at the diftance of fix feet from the fummit of the tree, and called *trompilles*.

The dimenfions of a good *trompe* are the following:

Length of the tree or wooden trunk, from its fummit to the fide apertures or trompilles, fix feet.

Length of the tree from the trompilles to the cafk, eighteen feet.

Height of the cafk, five feet.

Diameter of the cafk, four feet fix inches.

* I do not find in Lewis's Commerce of Arts, where this fubject is well treated, that the Englifh have called this machine by any appropriated name. T.

The form of the internal part of the trunk, above the trompilles, is that of a funnel, whofe fuperior opening is eighteen inches, and its inferior diameter five.

The diameter of the cavity of the tree, below the trompilles, is eighteen inches.

The diameter of the trompilles is fix inches.

The ftone upon which the water falls is eighteen inches in diameter.

When the mineral is once cleared of its gangue, its mineralizer, and all other foreign matter, it conftitutes what is called a metal, or regulus.

Every fact appears to prove that metals are fimple fubftances; the various alterations to which they are fubjected, being combinations of the metal itfelf with other fubftances. None of thefe operations either difengage or feparate any conftituent part of the metal itfelf, as we fhall fee.

Every metal is fufed at a certain degree of heat, more or lefs intenfe; and in this fituation their furface is convex.

Meffrs. Macquer and Lavoifier having expofed gold to the focus of the lens of Tfchirnhaufen, obferved that this metal exhaled in fumes, without being decompofed; as was proved by collecting it unaltered upon prefent-

ing

ing a plate of ſilver, which became gilt. Silver is volatilized in the ſame manner without decompoſition.

Metals fuſed, and cooled ſlowly, exhibit cryſtallizations of conſiderable regularity. The abbé Mongez, and Mr. Brogniart, have ſucceeded in cryſtallizing moſt of them, by varying the proceſs uſed by the celebrated Rouelle in the cryſtallization of ſulphur.

Moſt metals kept in a ſtate of fuſion loſe their metallic brilliancy, and become converted into an opake powder called Oxide, or Metallic Calx. The oxides, when urged by a ſtronger heat, are reduced into a vitriform ſubſtance, known by the name of Metallic Glaſs.

Metals acquire weight in their tranſition to the ſtate of oxide. This circumſtance has led ſeveral adepts into error, who imagined they had increaſed the weight of the metal.

Geber obſerves, "Ubi vel minimum augmenti metallici inveneris, ibi te dicimus eſſe ante fores philoſophorum."—"Et ſane conveniens judicium eſt," adds Becher; "id enim per quod corpus homogeneum augmentum capit, id ipſum eſt quod pro principio iſtius corporis haberi poteſt."—Phyſ. Subt.

Stahl pretended that the calcination of metals aroſe from the diſengagement of phlogiſton;

and he considered their calces as an earth, or metallic basis.

Boyle affirmed that the increase of weight in calcined metals was owing to the combination of the matter of fire; and Boerhaave ventured to attribute it to the surrounding bodies, which deposited themselves upon the metal. Of all the hypotheses which have been formed upon this subject, that of Stahl has met with the greatest number of supporters: and the blind zeal of his followers has carried them so far as even to disguise an unanswerable objection; namely, that it can never be explained how metals, by the loss of one principle, at the same time that they do not acquire another, can become heavier. The reduction of the oxides or metallic calces, without any addition of charcoal, cannot be explained on this hypothesis.

It must be confessed that all chemists were not of this way of thinking: and we find in the writings of Jean Rey, a physician of Perigord, that he in the year 1630 attributed the increase of weight in calcined metals to the combination of air with the metal. He affirms that agitation facilitates this combination in no other manner than water renders the sand heavy which is thrown and agitated in that fluid.

He reasons like a chemist of considerable skill,

ſkill, to prove that the increaſe of weight cannot be carried beyond a point of ſaturation; and he concludes his obſervations in theſe words: *Le travail a été mien; le profit en ſoit au lecteur, et à Dieu ſeul la gloire*—"Mine has been the labour; let the reader enjoy the advantage, and to God alone be the glory *."

All theſe ſeveral ſketches were never formed into a connected ſyſtem; and this doctrine was even completely unknown, when Mr. Lavoiſier proved to us that the calcination of metals was owing merely to the fixation of oxigenous gas, and their reduction to the diſengagement of this gas, effected by ſimple heat, or by its combination with various baſes in ſuch inſtances wherein its adheſion to the metal is too ſtrong to be overcome by mere heat. The proofs upon which this celebrated chemiſt has eſtabliſhed his opinion, are the following facts.

1. Metals are not oxided either in a vacuum, or in air which contains no part of oxigenous gas. The Count Morozzo, Prieſtley, Lametherie, and Pictet appear to have oxided lead,

* This is the ſame Jean Rey, who, being under the neceſſity of contradicting his friend Libavius on the theory of the calcination of metals, exclaims—"O Truth, how dear art thou to me! ſince it is in thy power to make me enter into a conteſt with ſo dear a friend."

tin,

tin, and mercury in the carbonic acid. See the Memoir of Mr. Sennebier, Journal de Phyſique, Fevrier 1787.—But this pretended oxide is nothing but a metallic carbonate, or the combination of a metal with an acid, which is very far from calcination or oxidation.

2. Metals incloſed under a glaſs, and properly heated, are oxided only by abſorbing the oxigenous gas contained in the maſs of air which is inſulated; and when this abſorption is ended, it is impoſſible to carry the oxidation any further.

3. Metals oxided in an atmoſphere of oxigenous gas abſorb it to the laſt drop.

4. Such oxided metals as are capable of being reduced in cloſed veſſels, give out, on their return to the metallic ſtate, the ſame quantity of oxigenous gas as they had before abſorbed.

This doctrine appears to me to be eſtabliſhed on the moſt complete ſeries of proofs which can be deſired in matters capable of demonſtration.

The concurrence of air and of humidity ſingularly aſſiſts the alteration of metals. The water is decompoſed in this proceſs, and its hydrogene is diſſipated, while its oxigene combines with the metal. This is doubtleſs the theory of ſuch oxidations as are effected beneath the

the furface of water; and when we find oxides, or metallic calces, in the bowels of the earth, defended from the contact of air, the facts ought to be referred only to the decompofition of water, or of acids which have oxigene for their bafe.

Hence it follows that the alteration of a metal will be the more fpeedy—1. In proportion as the affinity of the metal to oxigenous gas is ftronger. 2. As the quantity of oxigenous gas is greater. 3. As the air is more humid, &c. Metals decompofe certain fubftances in order to unite with their oxigene, and by that means to pafs to the ftate of oxide. This is obfervable when the nitric acid is digefted upon certain metals.

Metallic fubftances being confiderably numerous, it is neceffary to clafs them, that we may bring together fuch as poffefs fimilar properties, and feparate others which differ from them.

Ductility ferves as a leading character. Metals may be diftinguifhed into fuch as are ductile, and fuch as do not poffefs this property. The name of Metal has been peculiarly applied to the former, and that of Semi-metal to the latter kind.

Among the metals there are fome which are changeable by expofure to air, while others are

not sensibly altered in the same situation. This difference has caused a subdivision of the metals into perfect and imperfect metals.

We shall begin by treating of the semi-metals, because for the most part they approach to the saline or stony substances in their qualities; and we shall conclude with the perfect metals, because they possess the metallic qualities in an higher degree.

CHAP. I.

Concerning Arsenic.

THE substance which is sold in commerce under the name of Arsenic, is a metallic oxide of a glittering whiteness, sometimes of a vitreous appearance; exciting an impression of an acrid taste on the tongue; volatile when exposed to fire, in which situation it rises in the form of a white fume, with a very evident smell of garlic.

Although arsenic is most commonly met with under

under this form, it may be reduced to the metallic ſtate by treating it with oils, ſoaps, or charcoal in cloſed veſſels. The celebrated Becher was perfectly acquainted with this proceſs—" Si oleum, vel quodcunque pingue, arſenico miſceas, et per retortam diſtilles urgenti igne, ſublimabitur in collum arſenicum, inſignitur antimonii inſtar metallizatum."—The arſenic which ſublimes is of a brilliant grey colour, reſembling ſteel, but it ſpeedily becomes black in the air: it forms cryſtals, which Mr. De Liſle conſiders as aluminiform octahedrons.

Arſenic is ſometimes found native; and it is met with in ſtalactites, or in protuberant depoſitions formed of layers more or leſs diſtinct and concentric, which are ſeparable from each other like the coats of an onion, or the laminæ of ſhells, from which it has obtained the name of teſtaceous arſenic. In other inſtances the maſſes are formed of very ſmall ſcales; which renders the ſurface of the ſpecimen ſometimes granulated, and ſometimes full of ſmall cavities: it is then called ſcaly arſenic. Arſenic is alſo found in friable maſſes, poſſeſſing ſcarcely any conſiſtence. In theſe various forms we receive it from Bohemia, Hungary, Saxony, Saint Marie aux Mines, &c.

Arſenic is volatilized by an heat of about

144 de-

144 degrees of Reaumur. In order to ſet fire to this metal, it muſt be thrown into a crucible ſtrongly ignited; and then it exhibits a blue flame, and riſes in the form of a white oxide.

If it be ſublimed by a gentle heat, it cryſtallizes in trihedral pyramids or in octahedrons.

Arſenic is not ſoluble in water. Its ſpecific gravity is 57633, according to Briſſon. Its fracture reſembles that of ſteel, but it eaſily tarniſhes.

Arſenic appears to exiſt in the metallic ſtate in its combinations with cobalt in the teſtaceous cobalt ore, or with iron in miſpickel, according to the obſervation of Bergmann.

Arſenic unites by fuſion with moſt of the metals; but thoſe which were ductile before this addition, become brittle afterwards. Thoſe which are of difficult fuſion alone flow more eaſily by heat with the addition of arſenic, and thoſe which are very fuſible become refractory by the ſame addition. The yellow or red metals become white with this alloy.

Arſenic is often combined with metals in various ores, and is diſengaged from them by calcination. In various mine works, long winding chimneys are conſtructed, through which the arſenical vapours paſs, and in which they attach themſelves. The cruſt which is formed

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in proceſs of time againſt the internal ſurface of theſe chimneys is taken away, and is the ſubſtance met with in commerce under the name of arſenic. The cobalt ores of Saxony, which are torrefied to ſeparate this ſemi-metal, afford almoſt the whole of what is ſold. This oxide of arſenic is ſometimes native, and has been found in Saxony and Bohemia. It is very abundant in ſuch places as are ſituated in the vicinity of ſubterranean fires, ſuch as the Solfatara. It is often found cryſtallized in octahedrons, according to Mr. Sage.

The oxide is leſs volatile than the metal itſelf; and, as we have before obſerved, it emits a very evident ſmell of garlic. If it be ſublimed by a ſtrong fire in cloſed veſſels, it becomes tranſparent like glaſs; but its ſurface is ſoon rendered opake again by expoſure to air. It is not rare to find arſenical glaſs in the arſenic of commerce: it is yellowiſh, and ſoon loſes its tranſparency by expoſure to air. This glaſs is ſometimes found native in the cobalt mines, and among volcanic products.

Eighty parts of diſtilled water, at the temperature of twelve degrees, are required to diſſolve one part of the oxide of arſenic; but fifteen are ſufficient at the boiling heat.

One part of arſenic is ſoluble in between ſeventy and eighty parts of alcohol at the boiling heat.

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The oxide of arſenic partakes therefore of the properties of ſaline ſubſtances, and differs from the other metallic oxides—1. Becauſe it is perfectly ſoluble in water. 2. Becauſe the other metallic oxides are without ſmell, and fixed in the fire. 3. Becauſe thoſe oxides do not contract any union with metals.

On the other hand it reſembles the metallic oxides—1. In becoming converted into a metallic glaſs by a ſtrong heat. 2. In forming an opake inſoluble ſubſtance, poſſeſſing the metallic brilliancy when deprived of oxigene.

The oxide of arſenic is capable of combining with ſulphur; and the reſult is either orpiment or realgar, according to the manner of operating.

Moſt chemiſts have a notion that the realgar contains more ſulphur than the orpiment; and they have preſcribed different proportions to form theſe two ſubſtances. But it has been proved by Mr. Bucquet, that this difference of colour ariſes only from the manner of applying the fire; nothing more being neceſſary to convert orpiment into realgar, than the expoſing it to a ſtrong heat: and with the ſame mixture we may at pleaſure obtain either of theſe products, according to the manner of applying the heat.

Orpiment and realgar are found native in certain

certain places. Linnæus, Wallerius, Bergmann, and Cronſtedt have deſcribed them.

Cryſtals of realgar are found in Solfatara near Naples, according to Ferber; in the mines of Nagyag in Tranſylvania (ſee Forſter's Catalogue); in the mines of Felſobanya in Upper Hungary; in thoſe of Joachimſtal in Bohemia, and of Marienburg in Saxony.

Realgar is common in China; it is made into vaſes, pagods, and other ornamental works. The Indians make uſe of theſe veſſels to procure a purgative medicine: for this purpoſe they leave vinegar or lemon juice for ſeveral hours in the veſſel, and afterwards drink it.

Realgar is commonly found in the waters of volcanos. I have almoſt always obſerved it in compreſſed hexahedral priſms, terminating in two tetrahedral ſummits.

Orpiment is leſs ſcarce than the realgar. It almoſt always accompanies this ſubſtance; but the orpiment of commerce comes to us from various countries up the Levant, in irregular maſſes, ſolid or lamellated, and of a beautiful orange yellow. The Baron de Born informs us that it is met with, in polyhedral cryſtals, in a blueiſh clay near Newſol in Hungary.

Lime and the alkalis decompoſe theſe two

ſubſtances, and diſengage the oxide of arſe-nic.

The acids and the alkalis exhibit intereſting phenomena with arſenic.

The ſulphuric acid, when boiled on the oxide of arſenic, attacks and diſſolves it; but this oxide is precipitated by cooling. If the whole of the acid be diſſipated by a ſtrong heat, the arſenical acid remains behind.

The nitric acid, aſſiſted by heat, diſſolves the oxide of arſenic, and forms a deliqueſcent ſalt, of which we ſhall preſently treat.

The muriatic acid attacks arſenic very feebly. Meſſrs. Bayen and Charlard found its action very weak whether heated or cooled.

In order to form the ſublimed muriate of arſe-nic, or butter of arſenic, equal parts of orpi-ment and corroſive ſublimate of mercury are mixed together. The mixture is diſtilled by a gentle heat; and the receiver is found to contain a blackiſh corroſive liquor, which forms the ſub-limed muriate of arſenic. Cinnabar comes over if the heat be increaſed, according to the obſer-vation of Mr. Sage.

If pure pot-aſh be boiled on the oxide of ar-ſenic, the alkali becomes brown, gradually thick-ens, and at laſt forms a hard brittle maſs. This arſenical ſalt of Mr. Macquer is deliqueſcent.

It is ſoluble in water, which lets fall brown flocks. It is decompoſed by fire, and the arſenic eſcapes. Acids deprive it of its alkali, &c.

Soda exhibits phenomena nearly ſimilar with this oxide; and Mr. Macquer even affirms that he obtained this ſalt in cryſtals.

I have proved that ammoniac diſſolves the oxide of arſenic by heat; and I have ſeveral times obtained cryſtals of arſenic by ſpontaneous evaporation. I am even of opinion that the alkali is decompoſed in theſe circumſtances, that the nitrogene is diſſipated, while the hydrogene unites with the oxigene of the oxide, and forms water.

The oxide of arſenic haſtens the vitrification of all the earths; but the glaſſes into which it enters as a component part, have the property of eaſily becoming tarniſhed.

Equal parts of nitre and oxide of arſenic, diſtilled in a retort, afford a very red and almoſt incoercible nitric acid. Stalh and Kunckel obtained it by a proceſs nearly ſimilar. Macquer having reſumed this work, carefully examined the reſidue in the retort, and found that it was a ſalt ſoluble in water, capable of cryſtallizing in tetrahedral priſms terminated by four-ſided pyramids, unalterable in the air, fuſible by a moderate heat, but without becom-

ing alkalized. Mr. Macquer called it the neutral arſenical ſalt: he ſuppoſed that no acid could decompoſe it. But Mr. Pelletier proved that the ſulphuric, when diſtilled with it, diſengaged its acid.

The arſeniate of ſoda differs little from the arſeniate of pot-aſh. Mr. Pelletier obtained this ſalt cryſtallized in hexahedral priſms, terminated by planes perpendicular to their axes.

By theſe ſeveral experiments, Mr. Macquer had ſhewn that arſenic anſwered the purpoſe of an acid in theſe combinations. There remained only one ſtep therefore to be made, to prove that it was really metamorphoſed into an acid in theſe ſeveral operations: and it is to the celebrated Scheele that we are indebted for this diſcovery. His capital experiments upon mangeneſe naturally led him to it.

He has given us two proceſſes to obtain this arſenical acid; the firſt by means of the oxigenated muriatic acid, and the other by the nitric acid. Theſe acids are diſtilled from the oxide of arſenic: the muriatic acid abandons its oxigene to the oxide of arſenic, and reſumes the characters of the ordinary muriatic acid. The nitric acid is itſelf decompoſed; and one of its principles is diſſipated, while the other is fixed and combines with the arſenical oxide.

This

This acid is at preſent obtained by diſtilling ſix parts of nitric acid from one of oxide o arſenic.

Mr. Pelletier likewiſe propoſes to decompoſe the nitrate of ammoniac by the oxide of arſe-nic. The reſidue in the retort is the arſeniate of ammoniac, from which the alkali may be dri-ven by a fire long kept up. The reſidue is a vitreous maſs, ſtrongly attracting humidity, and falling into deliquium. It is the pure arſenical acid.

Mr. Pelletier has likewiſe decompoſed the neutral arſenical ſalt, by mixing it with half a part of oil of vitriol, and urging the fire to ſuch a degree as to ignite the veſſels. The reſidue at the bottom of the retort is a white maſs, which attracts humidity, and is the arſenical acid. A white powder is obſervable, which is found to be the ſulphate of pot-aſh or of ſoda, accord-ingly as the arſenical ſalt has ſoda or pot-aſh for its baſis.

From the various proceſſes made uſe of to form the arſenical acid, it is evident that this ſubſtance is nothing but the arſenical oxide, ſa-turated with the oxigene which it takes from the various bodies digeſted upon it. The nitric acid, or the nitrates uſed for this purpoſe, are de-compoſed; the nitrous gas paſſes over very

 abun-

abundantly, and the oxigene remains mixed and united with the oxide of arsenic.

This acid possesses the concrete form; but it attracts the humidity of the air, and becomes resolved into a fluid.

It is fixed in the fire; but if it be heated in contact with a coaly substance, it is decomposed, and the oxide exhales in the form of fumes. It is reduced into arsenic, according to Mr. Pelletier, by passing hydrogenous gas through it.

At the temperature of twelve degrees of the thermometer of Reaumur, this acid requires only two-thirds of its weight of water to dissolve it; whereas one part of the oxide of arsenic requires twenty-four of water to dissolve it at the same temperature.

This acid, when dissolved in water, may be again concentrated, and carried to the state of a transparent glass without any alteration; for it is not by this treatment deprived of its power of attracting humidity from the air.

When it is in this state of concentration, it acts strongly on the crucible, and dissolves the alumine, according to Mr. Berthollet's experiments.

The arsenical acid, saturated with ammoniac, and duly evaporated, forms a salt crystallized in rhomboides; which, when urged by heat, loses

loses its water of crystallization, next its alkali, and is resolved into a vitreous mass.

Barytes and magnesia appear likewise to have a stronger affinity with this acid than the alkalis, according to Bergmann. Lime decomposes the neutral salts with base of alkali, according to the experiments of the same chemist.

Arsenic is used by the dyers; it is likewise used as a flux in glass-houses, and in docimastic works; it also enters as a component part into some glazes. Orpiment and realgar are very much used by painters; but arsenic is one of those productions whose advantages are not sufficient to compensate for its bad effects. This metal, which is very abundant, and very frequently met with in mines, causes the destruction of a number of workmen who explore them: being very volatile, it forms a dust which affects and destroys the lungs; and the unhappy miners, after a languishing life of a few years, all perish, sooner or later. The property which it possesses of being soluble in water, multiplies and facilitates its destructive power; and it ought to be proscribed in commerce, by the strict law which prohibits the sale of poison to unknown persons. Arsenic is every day the instrument by which victims are sacrificed, either by the hand of wickedness or imprudence. It is often

miſtaken for ſugar; and theſe miſtakes are attended with the moſt dreadful conſequences. Whenever there is the leaſt reaſon to ſuſpect its preſence, the doubt may be cleared up by throwing a ſmall quantity of the powder upon heated coals. The ſmell of garlic, and the white fumes, are indications of the preſence of arſenic. The ſymptoms which characterize this poiſon are, a great conſtriction of the throat, the teeth ſet on edge, and the mouth ſtrongly heated; an involuntary ſpitting, with extreme pains in the ſtomach; vomiting of glairous and bloody matter, with cold ſweats and convulſions.

Mucilaginous drinks have been long ago given to perſons poiſoned by arſenic. Milk, fat oils, butter, &c. have been ſucceſſively employed.—Mr. Navier has propoſed a more direct counterpoiſon. He preſcribes one dram (gros) of ſulphure of pot-aſh, or liver of ſulphur, to be diſſolved in a pint of water, which the patient is directed to drink at ſeveral draughts: the ſulphur unites to the arſenic, and deſtroys its cauſticity and effect. When theſe firſt ſymptoms are diſſipated, he adviſes the uſe of mineral ſulphureous waters. He likewiſe approves of milk, but condemns the uſe of oils. Vinegar, which diſſolves arſenic, has been likewiſe recommended by Mr. Sage.

CHAP.

CHAP. II.

Concerning Cobalt.

COBALT was employed by artifts to give a blue colour to glafs, long before it was fuppofed to contain a femi-metal. We are indebted to Brandt, a celebrated Swedifh mineralogift, for the knowledge of its properties, and metallic character.

The fpecific gravity of fufed cobalt is 78119. See Briffon.

Cobalt is combined in the bowels of the earth with fulphur, arfenic, and other metallic fubftances.

1. The arfenical cobalt ore is of a grey colour more or lefs deep, dull in its fracture, and becoming black on expofure to the air, in confequence of an alteration in its arfenical part.

This ore of cobalt cryftallizes in fmooth cubes, and affects feveral varieties. I have a piece which has the form of tetrahedral pyramids, joined bafe to bafe. This fpecies of cobalt fometimes affects a confufed cryftallization in dendrites, and is then called Knit-cobalt ore. Sometimes it is found in protuberances, ftalactites, &c.

2. The

2. The ſulphureous ore of cobalt reſembles the grey ſilver ore in its texture: it contains iron and ſilver; and effloreſces of a lilac colour, mixed with a yellowiſh green.—Sage, Annal. Chem. t. ii.

Mr. De Liſle poſſeſſes ſpecimens of this kind, which came from the mine of Batnaes at Riddarhyttan.

3. Cobalt is mineralized by ſulphur and arſenic, in the mine of Tunaburg in Sudermania.

The cryſtallization of this ſpecies is a cube, ſtriated on its ſix faces, and commonly truncated more or leſs deeply on its edges.

This ore contains, according to Mr. Sage, fifty-five pounds of arſenic, eight of ſulphur, two of iron, and thirty-five of cobalt.

4. The ores of cobalt are ſometimes in effloreſcence; and the ſulphureous ore forms by its decompoſition the ſulphate of cobalt.

The ſulphure of cobalt, and the arſenical cobalt ore, paſs to the ſtate of oxide in their decompoſition; and the ſurface becomes covered with a colour of peach flowers, more or leſs intenſe. It is ſometimes coloured with an effloreſcence in the figure of ſtars formed by radii applied to each other collaterally, and all tending to a common centre. This is an indiſtinct cryſtallization, in which Mr. De Liſle thinks he obſerved

ſerved tetrahedral priſms terminated by dihedral ſummits. The flowers of cobalt are frequently a mere powder, more or leſs coloured. Thoſe ores which are in a ſtate of complete decompoſition are called Soft or Earthy cobalt ores.

To aſſay an ore of cobalt, the firſt proceſs is torrefaction. Two hundred grains are afterwards fuſed with an ounce and a half of black flux. Mr. Sage is confident that more metal is obtained by mixing the oxide of cobalt with two parts of white glaſs, and a ſmall quantity of coal.

When cobalt is mixed with biſmuth and iron, its oxide muſt be diſtilled with equal parts of the muriate of ammoniac, until the ſalt which ſublimes in the neck of the retort has acquired a green tinge. Mr. Sage, who gives us this proceſs, obſerves that ſeven or eight ſublimations are ſometimes neceſſary to deprive the cobalt of all the iron and biſmuth which it contains.

Cobalt is of a light grey colour, compact and brittle. It is not eaſily fuſed, is not volatile, reſiſts cupellation, and refuſes to amalgamate with mercury.

The working of cobalt ores is very ſimple. It conſiſts in roaſting the ore in a reverberatory furnace terminating in a long chimney, into which

which the vapours are received. Theſe vapours, or arſenical fumes, attach themſelves to the ſides, and form a cruſt, which is cleared off by criminals, who are condemned to this work for crimes that by the law deſerve death. The cobalt ores of Saxony afford all the arſenic of commerce. When the oxide of cobalt is cleared of arſenic, it is known by the name of Zaffer. The zaffer of commerce is mixed with three-fourths of ſand. This oxide, fuſed with three parts of ſand, and one of pot-aſh, forms a blue glaſs, which, when pounded, ſifted, and afterwards ground in mills, included in large caſks, forms Smalt. In order to obtain the blue of various degrees of fineneſs, the ſmalt is agitated in caſks filled with water, and pierced with three openings at different heights. The water of the upper cock carries out the lighteſt blue, which is called Azure of the Firſt Fire: the heavier particles fall more ſpeedily; and the azure brought out by the water of the three cocks, forms the different degrees of fineneſs known under the names of Azure of the Firſt, Second, and Third Fire.

Bohemia and Saxony have hitherto poſſeſſed the excluſive power of ſupplying us with theſe products. A deſcription of theſe capital works may be ſeen in the mineralogical productions of Meſſrs.

Meſſrs. Jars. The works of Saxony have been ſupplied, for ſeveral years, by the cobalt ore diſcovered in the Pyrenean Mountains, in the valley of Giſten. But the Comte de Beuſt has formed eſtabliſhments which ſecure to us the benefit of this commerce; and he has even been ſo fortunate as to find, near the village of Juget, a quartz ſufficiently charged with cobalt to admit of being fuſed without any addition of colouring matter.

The eſtabliſhment of the Comte de Beuſt is capable of manufacturing ſix thouſand quintals of azure, or enamel blue; and is able not only to ſupply our own wants, but to enter into competition with the works of Saxony for the foreign trade *.

He has likewiſe, in concert with the Baron Dietrich, diſcovered the proceſs of making powder blue; a ſecret which was excluſively in the poſſeſſion of the Hollanders till the preſent time.

Smalts are uſed in the preparation of cloths, laces, linens, muſlins, thread, &c.

The azures are mixed with ſtarch, and form the blue ſo well known and univerſally uſed by laundreſſes.

* A deſcription of the works of the Comte de Beuſt may be ſeen in the *Deſcription des Gîtes des Minérais, des Forges, et des Salins des Pyrénées, par M. le Baron de Dietrich.*

It

It is likewife employed in forming blue paintings on fayence, porcelain, and other potteries; cryftals and glaffes are coloured blue by this fubftance; and it is alfo ufed in painting in frefco.

The coarfeft blues are ufed by the confectioners and others, in the way of ornament; and in Germany they are ufed as fand for writing-paper.

The confumption of fmalt, azure, blue fands, and zaffers, in the kingdom of France only, is eftimated at four thoufand quintals, which are fold from feventy-two to fix hundred livres the quintal.

Cobalt is foluble in the acids.

One part of this metal, diftilled with four parts of fulphuric acid, affords the fulphureous acid; and the refidue in the retort is the fulphate of cobalt, foluble in water, and capable of cryftallizing in tetrahedral rhomboidal cryftals, terminating in a dihedral fummit.

Barytes, magnefia, lime, and alkalis decompofe this falt, and precipitate the cobalt in the form of oxide.

One hundred grains of cobalt diffolved in the fulphuric acid, and precipitated by foda, afford one hundred and forty grains of precipitate; and

and one hundred and ſixty when precipitated by chalk.

The nitric acid diſſolves cobalt with effervеſcence. The ſolution affords cryſtals in needles, which have not been ſtrictly examined. This ſalt is deliqueſcent, boils on the coals without detonating, and leaves a deep red calx. I have ſeen this ſalt in very ſhort beautiful hexahedral pyramids. It decrepitates and fuſes on charcoal.

The muriatic acid does not diſſolve cobalt in the cold, but by the aſſiſtance of heat it diſſolves a portion of it. This acid acts more effectually upon the zaffer, and the ſolution is of a very fine green, and when diluted with water conſtitutes a very ſingular ſympathetic ink; for it paſſes from a lilac, or violet colour, to purple, green, and black.

The nitro-muriatic acid likewiſe diſſolves cobalt, and forms the ſympathetic ink, which Hellot has called the Ink of Biſmuth.

Ammoniac likewiſe diſſolves zaffer, and produces a liquor of a beautiful red colour.

CHAP. III.

Concerning Nickel.

HYERNE appears to have been the firſt who treated of nickel, under the name of Kupfernickel, in 1694, in a work on minerals.

Henckel conſidered it as a ſpecies of cobalt, or arſenic mixed with copper.

Cramer has likewiſe placed it among the ores of copper; and it was not until the year 1751 that Cronſtedt obtained a new ſemi-metal from this pretended mixture.

Kupfernickel is found not only in the German diſtricts, but likewiſe in Dauphiny, and in the Pyrenean Mountains. In digging out a calcareous ſtone for building, at Bareges, and oppoſite St. Sauveur, ſmall veins and lumps of nickel were found in the calcareous ſpar, ſome parts of which were reduced to the ſtate of green oxide. Mr. Sage, who analyſed that of Biber in Heſſe, and that of Allemont, found it to contain gold.

In order to obtain nickel from its ore, it muſt firſt be torrefied to diſengage the arſenic; and the oxide muſt then be fuſed with three parts of black flux, and a ſmall quantity of coal. This metal is of a reddiſh grey colour.

The ſpecific gravity of fuſed nickel is 7,8070. Briſſon.

As it is very difficult to drive off all the arſenic by a previous torrefaction, the metal, when urged by a violent fire, ſtill ſuffers arſenic to eſcape.

The methods pointed out by Bergmann and Arvidſon to purify nickel, conſiſt in repeated calcinations and reductions: but theſe operations ſeparate the arſenic only; and Bergmann admits that he did not ſucceed in completely depriving it of its iron, though he treated it by every ſuitable method. He ſeems diſpoſed to conſider it as a modification of iron.

The Diſſertation of Bergmann De Nicolo, Opuſcula, t. ii. may be conſulted on the nature of this metal; and alſo the Analyſe Chimique of Mr. Sage, &c.

The ſulphuric acid diſtilled upon nickel affords ſulphureous acid, and leaves a greyiſh reſidue, which, when diſſolved in water, communicates to it a green colour.

The ſulphate of nickel effloreſces in the air.

Nickel is attacked very ſtrongly by the nitric acid. The ſolution, when evaporated, affords cryſtals of a beautiful green, in rhomboidal cubes.

The nitric acid likewiſe diſſolves the oxide of nickel, and forms with it deliqueſcent cryſtals of a fine emerald green, and of a rhomboidal form, according to Bergmann.

The muriatic acid diſſolves nickel, when heated. The ſolution produces cryſtals of the moſt beautiful emerald green, and of the figure of long rhomboidal octahedrons.

Cronſtedt has taught us that nickel combines with ſulphur by fuſion, and that the reſult is a hard yellow mineral, with ſmall brilliant facets. The ſame chemiſt diſſolved this laſt metal in the ſulphure of pot-aſh, and formed a compound reſembling the yellow copper ores.

Nickel does not amalgamate with mercury.

CHAP. IV.

Concerning Bismuth.

BISMUTH, or tin-glaſs, is a ſemi-metal of a ſhining yellowiſh white, diſpoſed in plates and chatoyant. It has ſome analogy with lead; and, like that metal, it paſſes off on the cupel, carrying the baſer metals along with it.

The ſpecific gravity of fuſed biſmuth is 9,8227.—See Briſſon.

Biſmuth is the moſt eaſily fuſed of all the ſemi-metals, after tin. It requires only the 200th degree of heat.

It is found in various ſtates in the bowels of the earth, either native, or combined with ſulphur, arſenic, or oxigene.

1. Native biſmuth is ſometimes cryſtallized in cubes: Wallerius and Cronſtedt found it in this form in the mines of Schneeburg in Saxony. Theſe cryſtals often re-unite in the form of dendrites, in the ſpathoſe or quartzoſe gangues. Native biſmuth is found in maſſes, covered with protuberances reſembling ſtalactites.

Native bismuth is frequently altered by a slight decomposition of its metallic surface.

The native bismuth of Saxony is sometimes irised, and mixed with arsenic: it has a reddish jasper for its gangue.

2. Arsenical bismuth is of a whitish and brilliant grey colour. This ore is sometimes covered with an ochre of bismuth, and often contains cobalt. I have seen pieces of arsenical bismuth, from Schneeburg, in the form of dendrites on a gangue of jasper.

3. We are indebted to Mr. Cronstedt for the knowledge of a sulphureous ore of bismuth. That which he has described is of a blueish brilliant grey colour.

This species frequently possesses the lamellated texture of the large plated galena, which has caused Linnæus, Wallerius, and others, to give it the name of Galena of Bismuth. It is found at Batneas, at Riddarrhitan in Westmanland. It decrepitates on heated coals, and requires to be pulverized, in order to torrefy it without loss.

The galena of bismuth is sometimes striated.

The sulphureous ore of bismuth is sometimes compact, of an obscure colour, sprinkled with small brilliant points. That of Schneeburg in Saxony is of this kind.

Mr. De la Peyrouse discovered, in 1773, on the mountains of Melles in Cominges, in the quarter called Les Raitz, an ore of bismuth, which resembles this small plated galena, and has no external difference, excepting that it is less heavy. This ore is mineralized by sulphur, in the proportion of thirty-five livres per quintal.

4. Cronstedt, Linnæus, Justi, and De Born, have spoken of a bismuth ore of a greenish yellow, found in Saxony, and in Sweden. Mr. Sage communicated to the Academy, on the 17th of August, 1780, the analysis of an earthy, solid, yellowish green ore of bismuth. He obtained quartz in the proportion of one-third, some carbonic acid, thirty-six pounds of bismuth per quintal, and twenty-four grains of silver: he found neither copper nor iron. Besides this green ore, he analysed a yellow, solid, slightly brilliant, and sometimes semi-transparent ore, which afforded him nearly the same results, but nine pounds more of bismuth.

This oxide must be fused in the blast furnace.

The fusibility of bismuth renders the working of this ore very simple, and the apparatus may be varied in several ways. Nothing more is necessary than to throw the ore into the fire, and to make a cavity underneath to receive the semimetal.

Bismuth, when heated to redness, burns with a blue flame, scarcely perceptible. Its oxide rises in the form of a yellowish fume, which, when condensed, forms the flowers of bismuth. Its weight is increased twelve per cent. in passing to the state of oxide.

Mr. Darcet has converted bismuth into a glass of a dull violet colour.

Bismuth may be substituted instead of lead, in the process of cupellation. Its vitrification is even more speedy.

The sulphuric acid, boiled on bismuth, suffers sulphureous acid to escape, and partly dissolves the semi-metal. The sulphate of bismuth does not crystallize, but is very deliquescent.

The nitric acid attacks bismuth, and is very speedily decomposed. Nitrous gas is disengaged, while the oxigene is fixed in combination with the metal. There is nevertheless a portion dissolved which is capable of forming a salt in rhomboidal, tetrahedral prisms, terminating in a tetrahedral pyramid with unequal faces. This nitre detonates weakly with reddish scintillations; and melts, swells up, and leaves an oxide of a greenish yellow colour.

This salt loses its transparency in the air, at the same time that its water of crystallization flies off.

The

The muriatic acid does not act on biſmuth but in the courſe of a conſiderable time; and for this purpoſe it muſt be highly concentrated. The muriate of biſmuth is of difficult cryſtallization, and ſtrongly attracts the humidity of the air.

Water precipitates this ſemi-metal from all its ſolutions; and the precipitate, when well waſhed, is known by the name of Magiſtery of Biſmuth, or white paint for the complexion. This white is uſed as a pigment for the ſkin; but ſtrong or ſulphureous vapours, and even the animal tranſpiration, convert it into metal, and alter its colours. The hair-dreſſers, when they are deſirous of converting hair to a black colour, ſmear it with a pomatum prepared with the magiſtery of biſmuth.

Biſmuth is uſed by the pewterers to give hardneſs to the metallic compoſition of pewter.

Mr. Pott has publiſhed a diſſertation, in which he affirms that phyſicians have made uſe of ſome preparations of this ſemi-metal: but it is proper that it ſhould be prohibited, becauſe it almoſt always retains a portion of arſenic, and itſelf partakes of the noxious properties of lead.

The white of biſmuth is very much uſed as a paint for the complexion. Its various ſolutions form ſympathetic inks, which are more or leſs

 curious,

curious, on account of the facility with which this oxide is altered, and becomes black.

Schluter, in his Treatife of the Fufion of Ores, pretends that it may be ufed in making the azure blue glafs. But it appears, from his own account, that he made ufe of a bifmuth ore very rich in cobalt. For he fays, that a moderate fire caufes this ore to fuffer its bifmuth to flow out, and that the refidue is a grey and fixed earth, which may be employed to advantage in making the blue.

This femi-metal unites with all the metals; but very difficultly, in the way of fufion, with the other femi-metals, or the metallic oxides. Antimony, zinc, cobalt, and arfenic refufe this union.

Bifmuth, fufed with gold, renders it eager, and communicates to it its own colour. It does not render filver fo brittle as gold: it diminifhes the red colour of copper, but is deprived of its own colour by uniting with lead; the two metals, in this cafe, forming an alloy of a dark grey colour. When bifmuth is mixed in a fmall proportion with tin, it gives it a greater degree of brilliancy and hardnefs. It may be united with iron by a violent heat.

Bifmuth amalgamates with mercury, and forms a fluid alloy; a circumftance which has

induced

induced certain unprincipled druggifts to mix it with that metal. The fraud may be known from the mercury being lefs fluid than before, and no other teft is neceffary than to diffolve the mixture in fpirit of nitre; for the bifmuth will be precipitated by the addition of water.

This property, however, of amalgamating completely with mercury, may caufe it to be applied with advantage in the filvering of glaffes, by an amalgam of tin, bifmuth, and mercury. This is, perhaps, the circumftance which has obtained it the name of tin-glafs.

The fufible alloy of Mr. Darcet is a mixture of eight parts of bifmuth, five of lead, and three of tin. It melts in water at the feventy-third degree of Reaumur, and flows like mercury.

CHAP. V.

Concerning Antimony.

ANTIMONY is a femi-metal which has fingularly engaged the attention of alchemifts. They confidered it as the bafis of their great

great work; and it is defcribed in their writings under the names of the Radical Principle of Metals, Sacred Lead, &c.

This femi-metal is famous for the difputes which were maintained concerning it, at the beginning of the fixteenth century. It was prohibited by a decree of parliament, at the folicitation of the faculty of Paris. Paumier, of Caen, a fkilful phyfician and chemift, was degraded by the Faculty of Medicine, for having employed it in 1609.

This fame profcribed metal was re-eftablifhed in 1624; and at prefent affords the moft powerful remedies poffeffed by the medical art.

Bazilius Valentinus, a zealous partifan of antimony, pleaded its caufe with much warmth and enthufiafm, in a work entitled Currus Triumphalis Antimonii: and Lemery has written a large volume to decry the preparations of this femi-metal.

As this fubftance afforded employment for a long time to the alchemifts, its ftudy is rendered particularly difficult by the multiplicity of preparations, and the barbarous names which have been given to them, and to the variety of proceffes. But by confounding preparations of the fame nature; by bringing the analogous products together, rejecting at the fame time the numerous lift

of barbarous names which have been beſtowed on one and the ſame thing; and by reducing the proceſſes to that ſimplicity of which the well-known preparations are ſuſceptible; we may ſucceed in forming an accurate and preciſe idea of the nature and properties of this metal.

Antimony is found in the bowels of the earth, in four different ſtates.

1. In the metallic form.
2. Combined with arſenic.
3. Mineralized with ſulphur.
4. In the ſtate of oxide.

1. Some authors pretend that antimony in the metallic ſtate was diſcovered in the year 1748, by Ant. Swab, in the mine of Sahlburg, in Sweden. Swab affirms that it has the colour of ſilver, that its texture is formed of large brilliant plates, and that it eaſily amalgamates with mercury. Cronſtedt, Wallerius, Linnæus, and Cartheuſer do not heſitate to admit of native antimony; but Lehman, Juſti, and Vogel deny its exiſtence: and Mr. De Liſle thinks that this pretended regulus is nothing but the white arſenical ore of antimony. The abbé Mongez affirms that he has diſcovered native antimony at Allemont in Dauphiny. It is the ſame ore which Mr. Sage has deſcribed under the name of the Arſenical Ore of Antimony.

If

If this native antimony really exiſts, it is probably cryſtallized like the metal itſelf, which is known to us, and whoſe cryſtals are either octahedrons inſerted one in the other, or cubes placed one upon each other ſlantwiſe.

2. The arſenical ore of antimony may be conſidered as a true regulus by thoſe who, after Bergmann, do not admit of arſenic as a mineralizer: for the ore is then conſidered as an alloy of the two reguli.

This ore is as white as ſilver, and exhibits large facets like antimony. The ſpecimen was ſent from Allemont in Dauphiny, to Mr. Sage. Its gangue is quartz. Small faſces of the grey and red ores of antimony ſtriated and radiated, and not containing arſenic, are ſometimes found in the cavities of this ſtone.

The antimony and the arſenic exiſt in the metallic ſtate in this ore. The arſenic adheres ſo ſtrongly to the antimony that it cannot be diſengaged by torrefaction. Mr. Sage combined the ore with ſulphur, and obtained orpiment and realgar. This mineralogiſt has concluded, from his analyſes, that the arſenic exiſted in the proportion of ſixteen pounds in the hundred.

3. Antimony is uſually mineralized by ſulphur, in which combination it exhibits three or four very diſtinct varieties. It is ſometimes cryſtal-

cryſtallized of a grey colour inclining to blue. The cryſtals are very frequently ſlender, oblong, hexahedral priſms, terminated by tetrahedral pyramids. The mines which are wrought in Auvergne afford us beautiful priſms, of the ſame geometrical form, but thicker than thoſe of the antimony of Hungary. Theſe laſt cryſtals ſoon become of an iriſed colour; but thoſe of the mines of Auvergne are not ſo ſpeedily changed. I poſſeſs a large ſpecimen of antimony from the neighbourhood of Alais, which is entirely covered with cryſtals perfectly ſimilar to thoſe of Hungary. It frequently happens that theſe cryſtals are confuſed and indiſtinct, in which caſe the ore appears to be formed of very ſlender priſms applied ſidewiſe to each other. That which is called plumoſe antimony does not differ from theſe varieties, excepting that its cryſtals are very ſlender and detached. They are uſually of a blackiſh grey. This variety has been arranged among the ores of ſilver, becauſe for the moſt part it contains that metal.

Ores of antimony have been found in ſeveral parts of France; but our province of Languedoc exhibits very curious ſpecimens. We have them at Malbos in the county of Alais. This mineral has been wrought in the dioceſe of Uzes; but the want of conſumption has prevented

vented the works from going on with spirit. Mr. De Gensanne has observed in Vivarais a large vein of ore of antimony in a stratum of pitcoal.

The decomposition of the sulphureous ore of antimony produces the red antimonial ore. The red ore more especially accompanies the specular antimony of Tuscany. Its surfaces appear to be corroded or rendered carious by decomposition; and when a piece is broken, it emits a powder which has the properties of kermes.

The decomposition of sulphureous antimony likewise produces the sulphate of antimony. Some varieties of these antimonial decompositions may likewise be seen in the Analyse Chimique of Mr. Sage.

Antimony is found in two states in the course of trade; namely, in the form of crude antimony, and in the metallic form.

Crude antimony is nothing else but the sulphureous ore of antimony cleared of its gangue. For this purpose the ore is put into pots pierced at the bottom, and disposed upon other pots buried in the earth. The uppermost pots which contain the mineral are then heated; the antimony becomes fused, and flows, together with its sulphur, into the lower vessels, while the gangue remains in the upper pots.

As

As the mixture of antimony and ſulphur is very fuſible, this proceſs may be varied in a thouſand ways. I have myſelf wrought an antimonial ore with the greateſt œconomy, by fuſing it in a furnace, over the arch of which I had diſpoſed the ore broken into pieces of five or ſix pounds weight each. The heat was communicated to the whole maſs by five openings in the arch or roof; and the antimony, as it melted, ran down on the outſide of the furnace by means of channels cut in the convex part of the dome. This method afforded forty quintals of antimony in twenty-ſeven hours, by the conſumption of between twenty and thirty quintals of combuſtible matter.

We are acquainted with two methods of depriving crude antimony of its ſulphur. 1. The ſlow and gradual calcination of the ore, which affords a grey oxide, and this urged by a violent heat is converted into a reddiſh and partly tranſparent glaſs of antimony. It does not aſſume this tranſparence unleſs it has been perfectly fuſed. The glaſs of antimony is a violent corroſive, but is capable of being corrected by mixing or kneading it with yellow wax, and afterwards burning off the wax; or otherwiſe by triturating it with a volatile oil. This is the cerated antimony of Pringle, ſo much extolled in dyſenteries. 2. Or

otherwiſe, the antimony may be deprived of its ſulphur by projecting into an ignited crucible a mixture of eight parts of crude antimony, ſix of tartar, and three of nitre. By keeping this mixture for a certain time in fuſion, the antimony is obtained in the metallic ſtate.

In the large works antimony is torrefied in an oven reſembling that of the bakers. Fifty pounds of dried wine lees or tartar are mixed with a hundred pounds of the oxide of antimony, and the mixture is then fuſed in proper crucibles. The metallic button contains the form of the crucible; and theſe loaves of antimony exhibit a ſtar on their upper ſurface, which has been conſidered as peculiarly characteriſtic; but is in fact nothing more than a confuſed cryſtallization formed by octahedrons inſerted one in the other.

Copper, ſilver, and iron, when fuſed with the ſulphure of antimony, ſeize its ſulphur, and reduce it to the ſtate of regulus. This has been diſtinguiſhed by the name of the metal employed. Thus we hear of the regulus of Mars, of Venus, &c.

Antimony is difficult of fuſion; but when once melted, it emits a white fume known by the name of Argentine Snow, or Flowers of Antimony. Theſe fumes, when collected, form very brilliant

brilliant prismatic tetrahedral cryſtals: Mr. Pelletier has obtained them in tranſparent octahedrons. The argentine flowers of antimony are ſoluble in water, which they render emetic. The volatility and ſolubility of this ſublimed oxide exhibit a reſemblance with the oxide of arſenic before treated of. We are indebted to Rouelle for theſe obſervations on the properties of this antimonial oxide.

Antimony is very ſlightly changed by expoſure to air, in which it long preſerves its brilliancy.

The ſpecific gravity of fuſed antimony is 6,7021.—See Briſſon.

The ſulphuric acid, by ſlow ebullition upon this metal, is partly decompoſed. Sulphureous gas firſt eſcapes, and ſulphur itſelf is ſublimed towards the end. When four parts of the acid are uſed with one of the antimony, the reſidue, after the action of the acid, conſiſts of the metallic oxide, with a ſmall quantity of the ſulphate of antimony, which may be ſeparated by means of diſtilled water. This ſulphate is very deliqueſcent, and is eaſily decompoſed in the fire.

The nitric acid is decompoſed upon this ſemi-metal with great facility. It oxides a conſiderable part, and diſſolves a portion, which may be ſuſpended in water, and forms a very

deliquefcent falt, decompofable by heat. The oxide prepared by this means is very white, and very difficult of reduction. It is a true bezoar mineral.

The muriatic acid acts upon antimony only by a long digeftion. Mr. Fourcroy has obferved that this acid, long digefted upon the metal, diffolves it; and that the muriate of antimony, obtained by a ftrong evaporation in the form of fmall needles, is very deliquefcent. It is fufible in the fire, and likewife volatile. Mr. Monnet has proved that twelve grains of the oxide of antimony are fufficient to faturate half an ounce of the ordinary muriatic acid. Meffrs. Monnet and De Fourcroy have always found that there is a portion of the muriate of antimony which is not volatilized by the fire: this depends upon its being ftrongly oxided or calcined.

If two parts of the corrofive muriate of mercury, and one of antimony, be diftilled together, a very flight degree of heat drives over a butyraceous matter, which is called butter of antimony, or the fublimed muriate of antimony. It may be prefumed that the acid in this compofition is in the ftate of oxigenated muriatic acid, as it is inthe corrofive fublimate.

The fublimed muriate of antimony becomes fluid

fluid by a very gentle heat; and by virtue of this property it may conveniently be poured from one veſſel to another: for nothing more is neceſſary than to plunge the bottle which contains it into hot water, and the muriate may then be poured out in its liquid ſtate.

I have ſeveral times obſerved this muriate of antimony cryſtallized in hexahedral priſms with dihedral ſummits: two ſides of the priſm are inclined, and form that which the ancient chemiſts diſtinguiſhed by the name of cryſtals in the form of a tomb. This muriate is uſed as an eſcharotic. When the ſalt is diluted with water, a white powder falls down, called powder of algaroth, or mercurius vitæ. This powder does not contain an atom of the muriatic acid, and is merely an oxide of antimony produced by that acid.

Simple water has ſome action upon this ſemi-metal; for we find that it becomes purgative by remaining in contact with it. Wine, and the acetous acid, completely diſſolve it: but the emetic wine is an uncertain remedy; becauſe it is impoſſible to determine with abſolute certainty the degree of its energy, which depends upon the very variable degree of acidity of the wine made uſe of. The emetic wine ought not therefore to be uſed but in external applications.

The gaſtric fluids likewiſe diſſolve this ſemi-metal, as is proved by the famous perpetual pills. This purgative has been diſtinguiſhed by the name of Perpetual Pills; becauſe, being very little alterable, the pill may be tranſmitted from generation to generation.

The acid of tartar forms a very well known ſalt with antimony, which is much employed in medicine, under the name of Emetic Tartar, Stibiated Tartar, or ſimply Emetic. It is this ſalt which, in the New Nomenclature, is diſtinguiſhed by the name of Antimoniated Tartrite of Pot-aſh.

In the examination of the various authors who have treated of the preparations of this remedy, as well as by comparing the moſt celebrated diſpenſatories, we do not find two which propoſe an uniform proceſs which is conſtant and invariable in its effects.

Some preſcribe the crocus metallorum, or ſemi-vitreous oxide of ſulphurated antimony; others the glaſs of antimony; others the liver of antimony, or ſulphurated oxide of antimony; and others the ſublimed oxide: ſome combine ſeveral of theſe ſubſtances. But all in general adopt cream of tartar, or the acidulous tartrite of pot-aſh, as a ſolvent.

The proceſſes vary not only in the choice of the

the ſubſtances to be made uſe of, but even in the proportions in which they are to be employed. We likewiſe find varieties in the quantity of water uſed as a vehicle, which is not an indifferent circumſtance; in the time preſcribed to digeſt the ſubſtances together, a circumſtance of the greateſt conſequence to be aſcertained, becauſe the ſaturation of the acid depends abſolutely and eſſentially upon it. The choice of veſſels muſt likewiſe influence the effect of this remedy. Hoffman has affirmed that the emetic loſt its effect by a long ebullition; and Mr. Baumé has proved that iron precipitates the antimony after a time, and conſequently that the iron veſſels preſcribed in certain diſpenſatories ought to be rejected.

This variety in the proceſſes muſt neceſſarily influence the reſult; and we cannot be much ſurpriſed that Geoffroy, who analyſed ſeveral antimoniated tartrites of pot-aſh, ſhould have found from thirty grains to two gros and ten grains of metal in the ounce of this ſalt.

Is it not therefore of great conſequence to preſcribe a uniform proceſs, whoſe product ſhould be invariable? Theſe heroic remedies, which operate in ſmall doſes, ought to produce conſtant and invariable effects through all Europe. It would be much more advantageous

that ſolemn proceedings ſhould be made for the preparation of theſe active remedies, than for the compoſition of the theriaca, a true pharmaceutic monſter, the doſe of which may with impunity be varied from a few grains up to three hundred. It follows, from the variety of the effects of theſe ſovereign remedies, that conſultations become almoſt ineffectual; becauſe the phyſician preſcribes according to the effects of the remedies he is in the habit of uſing: and the art of medicine becomes no better than a diſcouraging alternative of ſucceſs and diſappointment.

At Montpellier, the emetic acts in a doſe of one or two grains; but in other places it does not operate in a leſs doſe than ten or twelve: and the ſtibiated tartar ſold by thoſe wholeſale dealers in medicine, who ſupply the country apothecaries, is uſually nothing but the ſulphate of potaſh, or vitriolated tartar moiſtened with a ſolution of emetic. It is a thing greatly to be deſired, that government, which does not apply its ſtamp of approbation to objects of luxury until they have paſſed a rigid inſpection, ſhould prohibit traders from circulating with impunity products upon which the health of the citizen ſo eſſentially depends. Theſe are the frauds and deceptions which have engaged me to form an

eſta-

eſtabliſhment of chemical products, in which intelligence and probity preſide over all its operations; and I have ſucceeded in my laboratories ſo far as to conduct the proceſſes with ſufficient œconomy to afford products faithfully made up, and invariable in their effects, at the ſame price as thoſe ſophiſticated drugs with which the public has hitherto been poiſoned.

The moſt accurate proceſs for making an excellent emetic conſiſts in taking very tranſparent glaſs of antimony, grinding it fine, and boiling it in water, with an equal weight of cream of tartar, until this ſalt is ſaturated. By filtration, and evaporation with a gentle heat, and ſubſequent repoſe, cryſtals of the antimoniated tartrite of pot-aſh are obtained, whoſe degree of emeticity appears to be ſufficiently conſtant. The cryſtals may be obtained in ſeveral ſucceſſive products by repeated evaporations.

Macquer propoſed the powder of algaroth, as more uniform in its power. Meſſrs. De Laſſone and Durande have adopted the opinion of Macquer; and the celebrated Bergmann has followed the ideas of the French chemiſts, with a few ſlight modifications.

Take five ounces of cream of tartar reduced into powder, and two ounces two gros of the powder of algaroth precipitated by hot water,

 waſhed

washed and dried. Add water to these, and boil them gently. By filtration and evaporation the crystals of emetic tartar are obtained; which may be given in the dose of three grains, without fatiguing the stomach or intestines.

The antimoniated tartrite of pot-ash crystallizes in trihedral pyramids. It is very transparent, is decomposed on the fire with crackling, and leaves a coaly residue. Sixty parts of water dissolve it. It effloresces in the air, and becomes farinaceous. The solutions of this salt throw down a mucilage, which fixes, and forms a pellicle of considerable thickness: it is the mucilage of cream of tartar, which is insoluble in water, and partly soluble in alcohol. The sulphuric acid blackens it, but does not itself become coloured till after a long time. The nitric acid dissolves it partly; and is itself decomposed, with the emission of much nitrous gas.

The alkalis and lime decompose the antimoniated tartrite of pot-ash. Antimony, properly mixed with the nitrate, decomposes that salt completely. Equal parts of the semi-metal and nitre being thrown into an ignited crucible, the salt detonates, its acid is decomposed; and at the end of the operation the crucible is found to contain the alkali which served as the base of the nitrate, and the antimony reduced to the state

of

of white oxide : this is called Diaphoretic Antimony. The ſame preparation may be made by uſing the ſulphure of antimony ; in which caſe three parts of the nitrate are uſed to one of the crude antimony. The reſidue in the crucible, after the detonation, is compoſed of the oxide of antimony, fixed alkali, a portion of the nitrate not decompoſed, and a ſmall quantity of ſulphate of pot-aſh. This compound is ſtill known by the name of the Solvent of Rotrou. Water deprives it of all the ſalts it contains ; and leaves only the oxide of antimony, which is called Waſhed Diaphoretic Antimony. If a ſmall quantity of acid be poured on the fluid which holds the ſalts in ſolution, a ſmall portion of the oxide of antimony falls down, which was diſſolved by the alkali of the nitre. The precipitate forms the ceruſe of antimony, or the pearly matter of Kerkringius.

Equal parts of the ſulphure of antimony and of nitrate, detonated in an ignited crucible, form the liver of antimony, or ſulphurated oxide of antimony ; which, when pulverized and waſhed, produces the ſaffron of metals, or crocus metallorum.

The oxides of antimony have been conſidered as very difficult of reduction ; and it was not without ſurprize that I at firſt obſerved the facility

facility with which they are all reducible by the black flux. This prejudice was eſtabliſhed and propagated for want of proper experiments.

The alkalis do not ſenſibly act upon antimony: but the ſulphures of alkali diſſolve it completely; and it is upon this principle that an operation is founded by which we obtain a valuable remedy, known by the name of Kermes Mineral, to diſtinguiſh it from the vegetable kermes uſed in dying. The preparation is ſimply a red ſulphurated oxide of antimony. This remedy, firſt pointed out by Glauber, who made it with antimony and the ſolution of nitre fixed by charcoal, is indebted for its celebrity to the wonderful cures it performed in the hands of Simon, a Chartreux friar; whence it obtained the name of the Powder of the Chartreux. This religious man obtained the compoſition from a ſurgeon named Laligerie, to whom it had been given by Mr. Chaſtenay, lieutenant at Landau. Mr. Dodart, firſt phyſician to the king, bought the ſecret in the year 1720; and Mr. Laligerie rendered it public. According to his proceſs, the pounded ſulphure of antimony is boiled for two hours, with one fourth of its weight of the ſolution of fixed nitre or pot-aſh, in twice its weight of very pure water. After ebullition the fluid is filtered; the kermes falls

falls down as it cools, and is afterwards dried. Laligerie directs that more of the ſolution of fixed nitre be digeſted on the metal, till it is completely diſſolved. Laligerie burned ſpirit of wine or brandy upon it. The liquor which remains after the kermes is fallen down, contains more kermes, which may be diſengaged by means of an acid. This kermes, which is paler than the former, is known by the name of Golden Sulphur of Antimony, or the orange-coloured ſulphurated oxide of antimony.

This proceſs is no longer uſed. That which ſucceeded the beſt with me, conſiſts in boiling ten or twelve pounds of pure alkaline ſolution with two pounds of the ſulphure of antimony. The ebullition is continued for half an hour, after which the fluid is filtered; and much kermes is obtained by mere cooling. I digeſt new alkali on the antimony, until it is conſumed. The kermes which I obtain by this means is of a beautiful tufted appearance.

Geoffroy, who analyſed the kermes in 1734 and 1735, found that one gros of kermes contained from ſixteen to ſeventeen grains of antimony, from thirteen to fourteen grains of alkali, and from forty to forty-one of ſulphur. But Meſſrs. Baumé, Deyeux, de la Rochefoucauld, and De Fourcroy, are not convinced that the

the waſhed kermes contains an atom of alkali which is not neceſſary to its virtues.

Kermes is likewiſe one of thoſe remedies in the preparation of which the greateſt care ought to be taken. It is nevertheleſs a ſubſtance which all the apothecaries in the country buy at the fair of Beaucaire; and the analyſis which I have ſeveral times made of this kermes, has convinced me that it very often is nothing elſe but pounded brick, mixed with vegetable kermes, and ſprinkled with a ſtrong ſolution of emetic tartar. I have found ſome which was merely a mixture of the fine brown red and the calx of antimony.

Lime and lime-water, digeſted upon pulverized antimony, afford, even in the cold, at the end of a certain time, a kind of kermes, or golden ſulphur, of a beautiful red colour.

Antimony enters into the compoſition of printers types. It is likewiſe mixed with tin, to increaſe its hardneſs. It was formerly uſed as a purgative: for this purpoſe it was made into cups, in which water or wine was ſuffered to ſtand for a night, and taken by the patient the following day.

The ſulphure of antimony is uſed as a ſudorific in ſkin diſorders. For this purpoſe it is tied in a cloth, and digeſted in the ptiſans ap-

propriated

propriated to these disorders. It is administered in pills for the same purpose.

The solvent of Rotrou has been much used to dissipate lymphatic concretions, and pituitous swellings.

Washed diaphoretic antimony is used in considerable doses to excite perspiration. Some physicians have considered it as a medicine void of effect; and Boerhaave has maintained that its effect is not more considerable than that of Lemnian earth.

The kermes mineral is one of the most valuable medicines that the healing art is acquainted with. It is incisive; and may be administered in all pituitous cases, when the stomach fails, and the lungs are obstructed. In a more considerable dose it is sudorific, and a still larger portion is emetic. It is employed in the dose of from half a grain to three.

The tartar emetic has received its name from its uses. It is dissolved in water; and this solution produces its effect.

The liver of antimony, crude antimony, and the crocus metallorum, are more especially used as purgatives in the veterinarian practice. They are given to horses in the dose of about an ounce.

CHAP.

CHAP. VI.

Concerning Zinc.

ZINC is a metallic ſubſtance of a blueiſh brilliant white colour, very difficultly reducible into powder, but capable of being extended into very thin plates by the equal and gradual preſſure of the flatting mill. From this laſt property, which has been proved by Mr. Sage, we may conſider zinc as the intermediate ſubſtance between ſemi-metals and metals.

Zinc is found naturally in various ſtates.

1. Cronſtedt affirms that he ſaw a radiated cryſtallization of a metallic appearance, which is found at Schneeburg, where it is called flowers of biſmuth, but which he found to be the regulus of zinc. This celebrated mineralogiſt does not venture to pronounce that it is native zinc.

Mr. Bomare affirms that he found it in ſmall pieces in the mines of lapis calaminaris in the duchy of Limbourg, and in the zinc mines of

Goſlar.

Goſlar. This regulus may have ariſen from the ſcoriæ of furnaces, or from the ancient works; ſo that the exiſtence of native zinc is ſtill conſidered as very doubtful by theſe mineralogiſts.

2. Zinc is uſually mineralized by ſulphur, forming an ore known by the name of Blende, which in German ſignifies *blinding* or *deceitful*; a name which may have been given to it becauſe ſuch diſtricts as abound with this mineral are barren of other ores.

The determinate cryſtallization of blende appears to be the alumini-form octahedron, and ſometimes the tetrahedron; but the modifications of theſe primitive forms are ſo numerous, that the cryſtals are found in an aſtoniſhing variety of figures. Moſt commonly they are polyhedral cryſtals of an indeterminate form, or ſcarcely capable of being deſcribed. On this circumſtance depend the denominations of Blende with Large or Small Plates, Striated Blende, Compact Blende, and other ſpecies, which may be ſeen in the works of Meſſrs. Sage, De Liſle, &c.

The colour of theſe blendes is infinitely various; they are found yellow, red, black, ſemitranſparent, &c.

All the blendes emit an hepatic ſmell when grated or triturated.

There is a kind of blende which exhibits a line of phosphoric flame when scratched with a knife, or even with a tooth-pick. Mr. De Bournon found this yellowish, transparent, and phosphoric blende, similar to that of Scharffenburg, at Maronne in the mountains of Oisan, at the distance of nine leagues from Grenoble. The phosphoric blende contains scarcely any iron.

To make the assay of a blende, Mr. Monnet advises solution of the ore in aqua fortis. The acid unites with the metal, and separates the sulphur: after which the oxide of zinc may be obtained by distilling off the acid; and this may be reduced. Bergmann obtains one part of the sulphur of these ores by distillation, dissolves the residue in acids, and precipitates the metal from its solutions. Mr. Sage distils blende with three parts of sulphuric acid: the sulphur sublimes by this operation; and the residue in the retort is the sulphate of zinc, mixed with a small quantity of sulphate of iron, and other substances mixed with the zinc. I do not know any country where blende is wrought to obtain the zinc: but it is sometimes mixed with lead; and in the working of this last metal the former is occasionally obtained. Such is the ore worked at Rammelsburg near Goslar, in the lower Hartz. Great part of the zinc is dissipated during the fusion

fuſion of the lead ore; but a portion of this metal is obtained by a very ingenious proceſs. Care is taken to keep the anterior part of the furnace cool; againſt which a ſtone is placed with a ſlight degree of inclination. The vapours of the zinc which are carried againſt this ſtone, are condenſed, and fall in drops into powder of charcoal, with which a ſtone placed at the bottom is covered. The ſemi-metal is defended from oxidation by means of the charcoal; and it is afterwards fuſed, and caſt into convenient forms.

This zinc is always united with a ſmall quantity of lead, and is leſs pure than that which comes to us from India, under the name of Tutenag.

I ſtrongly calcined the blende of St. Sauveur, and mixed the powder with charcoal. I then put the whole into a retort whoſe orifice was plunged beneath water; and by a violent heat, kept up for two hours, I obtained much zinc, which fell to the bottom of the water.

3. The decompoſition of blende gives riſe to the formation of the ſulphate of zinc. The operation of nature is ſlow, but art has ſupplied its defect. All the ſulphate of zinc which is met with in commerce, is prepared at Rammelſburg. For this purpoſe, after having roaſted the galena mixed with the blende, it is thrown ignited into

 ciſterns

ciſterns full of water, where it is left for twenty-four hours. The roaſted mineral is three times extinguiſhed in the ſame water; after which the lixivium is evaporated, and put into coolers. At the end of fifteen days, the water is decanted, in order to ſeparate the cryſtals of the ſulphate of zinc. Theſe cryſtals are afterwards fuſed in iron veſſels; and the liquor is poured into coolers, where it is ſtirred till it congeals. We ſhall examine the properties of this ſalt in due courſe.

4. Zinc is likewiſe found in the ſtate of oxide; and it appears to me that nature makes uſe of two means of converting the metal to this ſtate. 1. The ſulphur is ſometimes diſſipated without the production of ſulphate: in which caſe it is replaced by the oxigenous gas, and the reſult is that oxide of zinc which is known by the name of Lapis Calaminaris. I have found ſtrata of lapis calaminaris, at St. Sauveur, intermixed with layers of blende; and the tranſition of the blende to the ſtate of lapis calaminaris may be followed in the moſt intereſting manner. 2. The ſulphate of zinc produced by the decompoſition of blende in certain circumſtances, is itſelf decompoſed by calcareous ſtones. In the rich collections of Meſſrs. Sage, De Liſle, &c. we ſee cryſtals of calcareous ſpar converted into calamine at one end, and calcareous at the other.

Calamine

Calamine cryſtallizes in rhomboidal tetrahedral priſms, or in hexahedral pyramids.

It is ſometimes covered with protuberances; often has the appearance of being worm-eaten; and is, at other times, either ſpongy or compact.

Its colour varies greatly. The county of Somerſet affords it of white, green, and other colours.

To make a good analyſis of calamine, Bergmann adviſes ſolution in the ſulphuric acid; he obtains the ſulphates of iron and of zinc. That of iron is decompoſed by a known weight of zinc; and the metal is afterwards precipitated by the carbonate of ſoda. He has aſcertained that ninety-three grains of this precipitate are equivalent to one hundred grains of zinc; and from this weight he deducts that of the zinc made uſe of to precipitate the iron.

Zinc may be obtained from calamine by diſtillation. For this purpoſe I have uſed the ſame proceſs as has already been mentioned in treating of blende.

Zinc yields beneath the hammer, without extending itſelf. If it be caſt into ſmall plates, it may then be laminated, and reduced into very thin and very flexible leaves.

The ſpecific gravity of fuſed zinc is 7,1908. See Briſſon.

Zinc, when heated, may be eaſily pulverized. This operation is very difficult without this precaution indicated by Macquer; for it wears and choaks up files, and deſtroys them in a ſhort time: beſides which, they have no conſiderable action upon it. It may likewiſe be fuſed and poured into water.—Theſe are the moſt convenient means of pulverizing it.

Zinc, treated in cloſe veſſels, ſublimes without decompoſition: but, when it is calcined in the open air, it becomes covered with a grey powder, which is a true oxide; and, if it be heated to redneſs, it takes fire, emits a blue flame; and white flocks iſſue from it, which are called Philoſophical Wool, Pompholix, or Nihil Album. This oxide may be fuſed into glaſs by an exceedingly violent heat: the glaſs is of a beautiful yellow colour. Zinc laminated into very thin leaves, takes fire by the flame of a taper, and burns with a blue colour mixed with green.

Mr. De Laſſone, who has written ſeveral excellent Memoirs on zinc, conſiders it as a kind of metallic phoſphorus.

Water appears to have ſome action upon zinc.

zinc. When this ſemi-metal begins to be ignited, if water be poured on it, the fluid is decompoſed, and much hydrogenous gas is diſengaged. Meſſrs. Lavoiſier and Meuiſner have aſcertained this fact, in their fine experiments on the decompoſition of water.

Sulphuric acid diſſolves it in the cold, and produces much hydrogenous gas. A ſalt may be obtained by evaporation, in tetrahedral priſmatic cryſtals, terminated by a four-ſided pyramid: Mr. Bucquet has obſerved that theſe priſms are rhomboidal. This ſalt is known by the name of Vitriol of Zinc, White Vitriol, Sulphate of Zinc: its taſte is conſiderably ſtyptic. It is not much altered by expoſure to air when pure; but ſuffers its acid to eſcape, at a degree of heat leſs than is required by the ſulphate of iron.

The nitric acid attacks zinc with vehemence, even when diluted with water. In this operation a great part of the acid is decompoſed; but if the reſidue be concentrated by ſlow evaporation, cryſtals are obtained in compreſſed and ſtriated tetrahedral priſms, terminated by pyramids with four ſides. Mr. De Fourcroy, to whom we are indebted for this obſervation, adds, that the ſalt melts upon heated coals, and ſpreads abroad with decrepitation, and a ſmall reddiſh flame. If it be expoſed to heat in a

crucible, it emits red vapours, assumes the consistence of a jelly, and preserves this softness for a certain time. The nitrate of zinc is very deliquescent.

The muriatic acid attacks zinc with effervescence. Hydrogenous gas is produced, and black flocks are precipitated, which somec hemists have taken for sulphur, others for iron, and which Mr. De Lassone considers as an irreducible oxide of zinc. This evaporated solution becomes thick, and refuses to crystallize. It suffers a very concentrated acid to escape when heated, and the muriate itself sublimes by distillation.

The pure alkalis boiled on zinc obtain a yellow colour, and dissolve a part of the metal, as Mr. De Lassone has proved. Ammoniac digested in the cold upon this semi-metal, disengages hydrogenous gas: this evidently arises from the decomposition of the water, which alone, and without any mixture, is decomposed upon ignited zinc, as we have already observed.

Zinc mixed with the nitrate of pot-ash, and thrown into an ignited crucible, causes this salt to detonate strongly.

Zinc decomposes the muriate of ammoniac by simple trituration, according to Mr. Monnet.

Pott

Pott has obſerved that a ſolution of alum, boiled upon the filings of zinc, is decompoſed, and affords the ſulphate of zinc.

Zinc fuſed with antimony, forms a hard and brittle alloy.

It unites with tin and copper, and forms bronze; when combined with copper alone, it forms braſs.

It is mixed with gunpowder, to produce the white and brilliant ſtars of artificial fire-works.

It has been propoſed to ſubſtitute this metal in the room of tin, for the internal lining of copper veſſels; and it is aſcertained, from the labours of Mr. Malouin, that this covering would be more uniformly extended upon the copper, and would be harder than tin. It has been remarked that vegetable acids might diſſolve it, and that theſe ſalts are dangerous; but Mr. De la Planche has made all the experiments on this ſubject which his extenſive knowledge, and zeal for the public good, could inſpire; and he is convinced that the ſalts of zinc, taken in a more conſiderable doſe than the aliments prepared in veſſels tinned with this ſemi-metal might contain, are not dangerous.

The ſublimed oxide of zinc is much employed by the German phyſicians, under the name of Flowers of Zinc. This remedy is

given as an antiſpaſmodic. It may be adminiſtered in pills, in the doſe of one grain. Tutty, or pompholix, is mixed with freſh butter, as an excellent remedy in diſorders of the eyes.

Mr. De Morveau has ſubſtituted the precipitate of zinc to white lead, with the greateſt advantage. It perfectly anſwers the intention of the artiſt, and is not attended with any dangerous conſequences in its uſe.

C H A P. VII.

Concerning Manganeſe.

A MINERAL of a grey or blackiſh colour, ſoiling the fingers, and uſed in glaſs-houſes under the name of Soap of the Glaſs-makers, has been long known in commerce. Moſt naturaliſts, ſuch as Henckel, Cramer, Gellert, Cartheuſer, and Wallerius, have placed it among the iron ores. Pott and Cronſtedt did not conſider it as a ferruginous ſubſtance. The latter found it to contain tin; and Mr. Sage

was long of opinion that it was an intimate alloy of zinc and cobalt.

The celebrated Bergmann, in the year 1764, declared in print, that black manganeſe ought to contain a peculiar metal; but he attempted in vain to extract it. However, Mr. Gahn, a phyſician at Stockholm, ſucceeded in obtaining a metal by the aſſiſtance of an exceedingly ſtrong fire. We ſhall explain his proceſs after having ſpoken of the different forms under which manganeſe is found in the earth.

Manganeſe appears to be always found in the ſtate of oxide; but this oxide exhibits ſeveral varieties.

1. It is ſometimes grey, brilliant, and cryſtallized, formed of very ſlender priſms confuſedly intertwined, and reſembling the ore of antimony; from which however it may be eaſily diſtinguiſhed by expoſing it upon charcoal. For antimony fuſes, and affords vapours; but the manganeſe remains unchanged.

The cryſtals of manganeſe are ſtriated, tetrahedral, rhomboidal priſms, terminating in four-ſided pyramids. They frequently diverge from a centre.

2. Manganeſe is very often black and friable. This ſpecies is found in the cavi-

ties

ties of the brown hæmatites of the Pyrenean Mountains.

I have discovered an ore at St. Jean de Gardonenque, in the Cevennes. It is prodigiously light, is found in strata, and in pieces which almost always have the figure of an hexahedral prism, eighteen lines in length, and thirteen or fourteen in thickness.

This ore, upon which I have made experiments that I shall presently recite, is the purest and finest I am acquainted with.

3. Manganese is sometimes of a reddish white colour, and composed of groups of protuberances. Its fracture is lamellated. That of Piedmont frequently has a grey, reddish tinge, and appears to be composed of small plates. It gives fire with the steel.

The manganese of Macon in Burgundy is of a deeper grey than that of Piedmont.

That of Perigueux is intermixed with yellow martial ochre. It is found in separate bodies, and not in veins like that of Piedmont.

4. Most of the white spathose iron ores contain manganese, and may be considered as ores of this semi-metal. Manganese is likewise mixed with calcareous spar, gypsum, jasper, æmatites, &c. Mr. De la Peyrouse has described

thirteen varieties of cryſtallized mangaueſe found in the Pyrenean Mountains.—See the Journal de Phyſique, Jan. 1780, p. 67.

5. Scheele has proved that the aſhes of vegetables contain manganeſe; and it is to this mineral that the colour of calcined pot-aſh is owing. To extract it, three parts of fixed alkali, one of ſifted aſhes, and one-eighth of nitrate, muſt be fuſed together. The fluid mixture muſt then be poured into an iron mortar, where it congeals into a greeniſh maſs. This being pounded, and boiled in pure water, muſt be filtrated, and ſaturated with ſulphuric acid. At the end of a certain time, a brown powder is depoſited, which poſſeſſes the properties of manganeſe.

To reduce manganeſe to the metallic ſtate, a crucible is lined with charcoal; and into a hole made in this charcoal, a ball of manganeſe, previouſly kneaded with oil and gum ammoniac, is to be put; after which the hole is to be covered with powder of charcoal. Another crucible muſt then be fitted on, and the veſſels expoſed to a violent fire for an hour and a half. By following this proceſs, I have ſeveral times obtained the metal from the oxide of manganeſe of Cevennes. I have even ſucceeded in reducing

ducing it, by simply putting the powder of manganese into a lined crucible.

The button which is obtained almost always has asperities on its surface. Globules appear which scarcely adhere to the mass; and these portions are usually of a considerably deep green, while the internal part has a blueish cast.

This metal is more infusible than iron. I have several times observed, when the fire has not been sufficiently strong to fuse the manganese, that several globules of iron have appeared dispersed through the agglutinated oxide.

Saline fluxes ought to be rejected, as insufficient for this reduction. The great disposition which this semi-metal has to become vitrified, causes it to be dispersed in the flux, where it remains suspended. I have several times, by using the vitreous flux of Mr. De Morveau, obtained metallic grains forming a button, or else dispersed in the flux; which, when more narrowly examined, proved to be nothing but iron, cobalt, or other metals, according to the nature of the ore of manganese. I have sometimes obtained even globules of lead; because the coarsest glass in which the presence of that metal is the least suspected, and which enters into the composition of the flux of Mr. De Morveau, contains it very often.

The

The ſpecific gravity of manganeſe has been eſtimated by Bergmann, in proportion to that of water, nearly as 6850 to 1000.

The oxide of manganeſe, when ſtrongly heated in cloſe veſſels, affords a prodigious quantity of oxigenous gas, and begins to afford it at a degree of heat leſs than is neceſſary to diſengage it from the oxides of mercury: a ſtrong fire is required to diſengage the laſt portions. Four ounces of the manganeſe of Cevennes afforded me nine pints of oxigenous gas. The reſidue in the retort was a grey oxide; one part of which was incruſted in the fuſed glaſs, and had communicated to it a very rich violet colour.

The oxide of manganeſe, diſtilled with charcoal, affords the carbonic acid: but, if it be calcined in an open veſſel, it is reduced into a grey powder, which loſes conſiderably of its weight when the fire is very ſtrong; and at length agglutinates, and forms a green maſs.

If it be mixed with charcoal, it does not ſuffer any perceptible change in its colour.

Manganeſe, expoſed to a very violent heat, vitrifies, and affords a glaſs of an obſcure yellow colour. The iron which is mixed with it preſerves its metallic form.

Manganeſe is eaſily changed in the air, and

is

is reſolved into a brown powder of a greater weight than the ſemi-metal itſelf: a certain proof of oxidation.

Manganeſe unites eaſily by fuſion with all the metals except pure mercury. Copper alloyed with a certain quantity of manganeſe is ſtill very malleable.

If a mixture of the phoſphate of urine with a ſmall quantity of oxide of manganeſe be placed upon charcoal, and be kept in fuſion for a few inſtants by means of the blue interior flame of the blow-pipe, a tranſparent glaſs will be produced, of a blue colour inclining to red; which, when charged with a certain quantity of the ſalt, aſſumes the colour of a ruby. If it be kept in fuſion for a longer time, a ſlight effervеſcence is perceived, and all the colour diſappears. If the tranſparent globule be then ſoftened by the exterior flame, the colour ſoon returns, and may be again effaced by keeping up the fuſion for a time. The ſmalleſt portion of nitrate, added to the glaſs, immediately reſtores the red colour; and, on the contrary, it is deſtroyed by the addition of ſulphuric ſalts. This globule of glaſs, taken from the charcoal, and fuſed in the ſpoon of perfect metal, becomes red, and changes no more. Theſe experiments were made by the celebrated Bergmann.

The

The ſulphuric acid attacks manganeſe, and produces hydrogenous gas. This metal is diſſolved more ſlowly than iron; a ſmell is diſengaged ſimilar to that which is afforded by the ſolution of iron by the muriatic acid. The ſolution is as colourleſs as water, and affords by evaporation tranſparent colourleſs cryſtals in the form of parallelopipeds, and of a bitter taſte. Mr. Sage obtained them in tetrahedral priſms, terminated by four-ſided pyramids. This ſalt effloreſces in the air.

If the ſulphuric acid be poured on the oxide of manganeſe, and its action aſſiſted by a gentle heat, an aſtoniſhing quantity of oxigenous gas is diſengaged. The oxide of manganeſe of Cevennes afforded me five pints and a half per ounce. When this oxide is deprived of its oxigene, the reſidue is a white powder, ſoluble in water, which by evaporation affords the ſulphate of manganeſe, already deſcribed.

The celebrated Bergmann has obſerved that coaly matter, ſuch as ſugar, honey, and gum, aſſiſted the action of the acid. This depends on the combination of the oxigene with theſe agents, to form the carbonic acid; and the ſulphuric acid acts more eaſily upon the metal itſelf.

Manganeſe is precipitated from its ſolutions by

by the alkalis, in the form of a whitiſh gelatinous matter; but this precipitate ſoon loſes its colour, and becomes black by the contact of the air. This phenomenon, which I have myſelf been a witneſs to, can be attributed, in my opinion, only to the abſorption of oxigenous gas: and I was convinced of this truth by agitating the precipitate in bottles filled with this gas; for in this ſituation the black colour is produced in one or two minutes, and a conſiderable part of the gas is abſorbed. I have conſtructed an eudiometer as certain and as invariable as that which the liquid ſulphure of pot-aſh, or ſolution of liver of ſulphur, affords; but a large quantity of precipitate is required, which muſt be agitated againſt the ſides of the veſſels, in order that it may preſent a greater ſurface to the air, and that the abſorption may be more ſpeedy. I judge of the abſorption by cauſing the veſſel to communicate, by a graduated tube, with ſtanding water. The aſcenſion of this water in the tube is proportionate to the volume of oxigenous gas abſorbed.

The nitric acid diſſolves mangaueſe with effervescence. There always remains a black, ſpongy, and friable body, which exhibited to Bergmann all the characters of molybdena. Other ſolvents preſented a ſimilar reſidue. The ſolu-

solution of the nitrate of manganese has frequently a dull colour, and assumes the red colour with difficulty. This solution does not afford solid crystals, even by slow evaporation.

The oxides of manganese are soluble in the nitric acid. It is observable that this acid is not decomposed upon them, because it finds the metal in the state of oxide. Carbonic acid is afforded when coaly substances are added to assist the solution. When the nitrous or fuming nitric acid is used, the solution is made without the assistance of these coaly substances, because the excess of nitrous gas seizes the oxigene of the oxide. These solutions do not crystallize.

The muriatic acid dissolves manganese; but when it is digested upon the oxide it seizes the oxigene, and passes in vapour through the water. This vapour is known by the name of Oxigenated Muriatic Acid, whose properties we have already explained.

The residue in the retort consists of a portion of acid combined with the manganese. This by evaporation affords a saline mass, which attracts the humidity of the air.

The fluoric acid with manganese affords a salt of sparing solubility, and this acid dissolves but little of it: but by decomposing the sulphate, the nitrate, or the muriate of manganese

 by

by the fluate of ammoniac, a fluate of manganese is precipitated. The same phenomenon takes place with the phosphoric acid. The acetous acid has but a weak action upon this substance. If it be digested upon the oxide of manganese, it acquires the property of dissolving copper, and forms the beautiful acetate of copper, or crystals of Venus; whereas the same acid, digested on copper, forms verdigris, or simply corrodes it. This circumstance proves that the acetous acid becomes charged with oxigenous gas, by the assistance of which it dissolves the copper.

The oxalic acid not only dissolves manganese, but likewise the black oxide of manganese. The saturated solution deposits a white powder if there be not an excess of acid. This salt is blackened by the fire, but easily resumes the milky colour in the same acid. The oxalic acid precipitates it in the form of small crystalline grains, when poured into solutions made by the sulphuric, nitric, or muriatic acids.

The acidulous tartrite of pot-ash dissolves the black oxide, even in the cold. The tartrite of pot-ash added to any solution whatever of manganese, occasions a precipitate which is a true tartrite of manganese.

The carbonic acid attacks manganese and the

the black oxide. The ſolution becomes covered in the open air with a pellicle, which conſiſts of mangaueſe that is ſeparated and oxided. It is white when it does not contain iron.

If the muriate of ammoniac be diſtilled with this oxide of manganeſe, an elaſtic fluid is diſengaged, according to the obſervation of Scheele, which he conſiders as one of the principles of ammoniac, without determining its nature. Mr. Berthollet has proved that, when ammoniac is diſengaged by a metallic oxide, there is a portion decompoſed. The oxigene of the oxide unites to the hydrogenous gas of the alkali to form water, and the nitrogene gas eſcapes.

Eight parts of oxided manganeſe take up, by a gentle heat, in a glaſs retort, three parts of ſulphur; and produce a maſs of a greeniſh yellow colour, which acids attack with an effervefcence and hepatic ſmell.

Manganeſe itſelf does not appear to combine with ſulphur.

In order to ſeparate iron from manganeſe, the alloy muſt be diſſolved in the nitric acid, and evaporated to dryneſs. The reſidue muſt be ſtrongly calcined, and digeſted with weak nitric acid, and a ſmall quantity of ſugar. The

acid takes up the manganeſe, which may be precipitated by the carbonate of pot-aſh.

The alloy may likewiſe be put into a ſolution of the ſulphate of iron. The acid abandons the iron to unite with the manganeſe.

The iron having leſs affinity with the acid than the manganeſe, may likewiſe be precipitated by a few drops of alkali.

The oxide of manganeſe is chiefly uſed in glaſs-houſes, to deprive glaſs of its green or yellow colour, which ſoda and ſand, when fuſed together, uſually aſſume. It has on this account been called the Soap of the Glaſs-makers. It is alſo uſed to colour glaſs and porcelain of a violet colour.

The conſumption of this mineral is become more conſiderable ſince the diſcovery of the oxigenated muriatic acid, which has pointed out its uſes in bleaching of linen, cotton, &c.

CHAP.

CHAP. VIII.

Concerning Lead.

LEAD is the ſofteſt, the leaſt tenacious, the leaſt ſonorous, the leaſt elaſtic, and one of the moſt ponderous, of metals. A cubic foot of lead weighs ſeven hundred and ninety-four pounds, ten ounces, four gros, forty-four grains. Its ſpecific gravity is to that of water as 115523 to 10000, according to Briſſon. Its fracture is of a blueiſh white colour, darker than that of tin, and tarniſhing in the air. It poſſeſſes a peculiar ſmell, which is rendered perceptible by friction.

A gentle heat is ſufficient to fuſe lead; and the abbé Mongez obtained it in cryſtals of the form of quadrangular pyramids, recumbent on one ſide. Some authors affirm that lead is occaſionally met with in the native ſtate. Wallerius mentions three pieces of this kind. The German mineralogiſts likewiſe affirm that it has been found native in Villach in Carinthia. Mr. Genſſane found in Vivarais, in four places,

at Serremejanes, at Fayet near Argentiere, at St. Etienne de Boulogne, and near Villeneuve de Berg, " grains of native lead, from the ſize " of a cheſtnut to an almoſt imperceptible " degree of ſmallneſs; they are all included " in a very ponderous metallic earth, which is " preciſely of the colour of the aſhes of beech, " or of litharge reduced to an impalpable " powder. This earth may be cut with a knife, " but requires the hammer to break it." He found pieces which contained a ſubſtance ſimilar to litharge in their internal part.

Linnæus ſpeaks likewiſe of a native lead in cryſtals.—Moſt naturaliſts agree to conſider native lead as of a very problematical exiſtence. The various ſamples found in cabinets are probably owing to ancient mine works. Time has changed their appearance, and incruſted them with various matters, which ſeem to prove that they do not owe their formation to the action of fire; and this is the circumſtance which may have impoſed on certain naturaliſts.

1. Lead is uſually mineralized by ſulphur; and this ore is known by the name of Galena.

It uſually cryſtallizes in cubes, and in all the varieties of that figure.

Galena is diſtinguiſhed into ſeveral ſpecies. 1. Large diced galena. 2. Small diced galena.

lena. 3. Scaly or plated galena. 4. Compact galena, in ſmall brilliant grains reſembling ſteel. It does not appear to be lamellated.

Theſe diſtinctions are more eſpecially neceſſary to be attended to, becauſe the ſpecies are very different in richneſs, and the alloy of ſilver, which is inſeparable from galena. In general, the large diced galena is poor in ſilver, and is uſed to give a glaze to pottery, by the name of Alquifoux, or potters lead ore. That which is in ſmall grains is richer, and is wrought as a lead ore containing ſilver.

Galena is the only ſpecies of lead ore which is worked; and we ſhall relate all we have to ſay concerning the working and aſſay of lead ores after having ſpoken of the other ores.

2. Lead has been found mineralized by the ſulphuric acid. Mr. Monnet has called this ore the pyritous lead ore. It is friable, dull, black, and almoſt always cryſtallized in very long needles, or in ſtalactites. It effloreſces in the air, and affords a true ſulphate of lead. This appears to be of the nature of galena: for as the ſulphate is not developed but by the effloreſcence of the ore, it may be concluded that the ſulphuric acid does not exiſt in the virgin ore itſelf.

Lead mixed with iron is ſometimes combined

with the ſulphuric acid. A large quantity is found in the iſland of Angleſea. It cannot be reduced upon charcoal with the blow-pipe, but it fuſes into a black glaſs.—Dr. Withering has indicated this ore.

3. The carbonic acid very often mineralizes lead, and exhibits ſome varieties which we ſhall proceed to deſcribe.

A. The white lead ore.—This is almoſt always found in the cavities of decompoſed galena, or in the veins of powdery ſtone containing galena. It is heavy, and frequently of a greaſy colour; decrepitates in the fire; and is eaſily reduced by diſtillation, affording only water and the carbonic acid. Its form is almoſt always cryſtalline, but varies prodigiouſly. The primitive form appears to be a dodecahedron, with iſoſceles triangular planes.

I have ſeen cryſtals accurately of the form of an hexahedral priſm ſometimes terminated by a ſix-ſided pyramid. The ores of St. Sauveur in the Cevennes have afforded us this variety; Mr. Sage poſſeſſes white lead ore of Geroldſeck cryſtallized in cubes.

White lead as tranſparent as flint glaſs has been found in England and in Siberia.

The analyſis of the white lead of Siberia afforded Mr. Macquart, per quintal, ſixty-ſeven

ſeven parts lead, twenty-four carbonic acid, ſix oxigene, and three water.

B. Green lead ore.—This differs from the foregoing only in the modifications produced by the colouring principle, which is copper, according to Spielman; and iron, according to the greateſt number of chemiſts. Its form is uſually that of a truncated hexahedron; and this ore is not ſo eaſily reduced as the white ore.

C. The black ore of lead.—Lead may return to the ſtate of galena by reſuming the ſulphur it had loſt; and this regeneration is not rare. It is enough that any hepatic vapour ſhould ſtrike the ore to effect this converſion. The ores of Tſchopau in Saxony, and thoſe of Huelgoet in Lower Britanny, exhibit fine inſtances of this phenomenon.

The gradations or intermediate ſpecimens of theſe different ores, eſtabliſh an infinite number of ſpecies, which the naturaliſt can never admit but as varieties. The tranſition of the white lead ore to the black ore exhibits gradations of colour which it would be very ſuperfluous to deſcribe.

In the year 1766, Mr. Lehmann deſcribed a new ſpecies of lead ore, called Red Lead. It was found in Siberia, in the environs of Catherine-

burg.

burg. Its cryſtals are grouped, and adherent to quartz, to copper ores, or iron; and ſometimes to galena, with cryſtals of white and green lead. It is frequently cryſtallized in rhomboidal tetrahedral priſms, ſhort, and truncated obliquely.

Mr. Sage has conſidered this lead ore as a variety of the preceding ſpecies, coloured by iron, of which Mr. Lehmann has proved the exiſtence. The abbé Mongez thinks it is mineralized by the arſenical acid.

Mr. Macquart has given us the moſt valuable information reſpecting the red lead ore; and has proved by an accurate analyſis that it contains, in the quintal, lead thirty-ſix, oxigene thirty-ſeven, iron twenty-five, and alumine two.

4. The phoſphoric acid has likewiſe been found naturally combined with lead. This ore, diſcovered by Gahn, owes its green colour to iron. It does not effervеſce with acids. In order to aſſay it, it muſt be diſſolved in the nitric acid by the aſſiſtance of heat, and the lead may then be precipitated by the ſulphuric acid. The ſupernatant liquor being decanted off, and evaporated to dryneſs, affords the phoſphoric acid.

This ore melts by the blow-pipe, and affords an opake globular maſs without reduction. Its habitudes

habitudes with fluxes refemble thofe of lead and its oxides.

Mr. De la Metherie has informed us that Mr. * * *, an Englifh gentleman, by treating lead ores with the blow-pipe, had obferved that there was one whofe globule cryftallized by cooling, after having been in perfect fufion; and that thefe ores were not reducible by the blow-pipe. He fufpected they were mineralized by the phofphoric acid. Mr. De la Metherie and this gentleman took feven ounces of the green lead ore of Hoffsgruard, near Fribourg in Brifgaw; which, when treated by the forego- ing procefs, afforded them phofphoric acid. The phofphoric acid combined with minium afforded them a green compound.

The decompofition of the ores which we have defcribed frequently affords the oxides of lead, or calciform ores.

Thefe oxides at firft afford a powder which, being carried along by waters, often mixes with argillaceous, calcareous, or quartzofe earths.

Thefe oxides vary more particularly in their colour, which affimilates them more or lefs perfectly to cerufe, mafficot, or minium.

In order to make the affay of a galena, it muft be pulverized and torrefied. The torrefied mi-

neral

neral, mixed with three parts of black flux, affords by fuſion a metallic button, which indicates the proportions of the lead in the quintal of the ore.

Bergmann propoſes to make the aſſay of ſulphureous lead ores by the nitric acid, which diſſolves the lead and not the ſulphur. The ſolution is then to be precipitated by the carbonate of ſoda; and one hundred and thirty-two grains of the precipitate are equivalent to one hundred of the metal. If the ore contains ſilver, ammoniac is to be digeſted on the precipitate, from which it diſſolves the oxide of ſilver.

The various operations to which lead ore is ſubjected to obtain the lead, are—1. It is ſorted, to ſeparate the rich or pure ore from the pulverized matter, and the gangue which contains no metal. 2. The ore is pulverized, and its gangue ſeparated by waſhing. 3. The ore is roaſted in a reverberatory furnace, with occaſional agitation, that it may preſent all its ſurfaces to the air; and when the external part begins to aſſume the form of a paſte, it is covered with charcoal, the mixture is ſtirred, and the heat increaſed. The lead then runs on all ſides, and is collected at the bottom of the furnace, which is pierced, and permits the metal to flow

into a receptacle properly defended by a lining of charcoal.

The ſcoriæ, which ſtill retain much lead, are fuſed by a blaſt furnace: the lead is caſt into pigs for ſale.

To diſengage the ſilver which the lead may contain, it is carried to the refining furnace; where, by the united energy of fire, and the wind of bellows directed upon the melted lead, the metal is converted into a yellow ſcaly oxide, called Litharge. This litharge is driven off in proportion as it forms; and the ſilver remains alone in the middle of the cupel. The colour cauſes a diſtinction of the litharge into litharge of gold, or litharge of ſilver. When the litharge is fuſed in contact with charcoal, it reſumes its ſtate of metal; and the lead is ſo much the better, in proportion as it has been deprived of the ſilver it contained. The ſmalleſt alloy of fine metal renders it brittle.

Lead is fuſible by a gentle heat. If it be kept for ſome time in fuſion, it becomes covered with a grey oxide; which, when expoſed to a more violent heat, capable of keeping it ignited, aſſumes a deep yellow colour, in which ſtate it is called Maſſicot. Maſſicot may be converted into the red oxide, or minium, by the following proceſs. When the lead is converted into

into maſſicot, it is thrown out, and cooled by pouring water upon it; after which it is carried to the mill, and ground into very fine powder, which is waſhed in water. The particles of lead which could not be pulverized in the mill, remain in the veſſel where the waſhing is performed.

This oxide of lead is ſpread out upon the hearth of the furnace in which it is calcined. Lines are drawn on its ſurface; and it is ſtirred from time to time, that it may not clot together; and the fire is kept up for forty-eight hours. When the minium is taken out of the furnace, it is put into large ſieves of wood, and paſſed through very fine net work, or cloth of iron wire, placed over the caſks which receive the minium. We are indebted to Meſſrs. Jars for this information, who have given very curious details reſpecting the manufactories of minium in the county of Derby.

Mr. Geoffroy was of opinion, that, in order to form minium, no greater heat was required than one hundred and twenty degrees of Reaumur's thermometer. But this heat is not adapted to works on a large ſcale; for in theſe the roof of the furnace is kept at a red heat. The lead increaſes in weight ten per cent. by the calcination.

All theſe oxides, urged by a ſtronger heat, are converted into a yellow glaſs, ſo very fuſible, that it penetrates and deſtroys the beſt crucibles. It is uſed in glaſs houſes, on account of its fuſibility, not only to aſſiſt the fuſion, but likewiſe to render the glaſs ſofter, more ponderous, of a more unctuous feel, and more ſuſceptible of being cut and poliſhed. Theſe are the reaſons for which it is made a part of the compoſition of flint glaſs, and cryſtal glaſs.

The oxides of lead, diſtilled without addition, afford oxigenous gas by a violent heat.—Prieſtley obtained it from minium, part of which was converted into globules of metal.

When theſe oxides are fuſed with coaly matter, the metal becomes revived.

The ſulphuric acid boiled upon lead affords much ſulphureous acid; and an oxide is formed, which ariſes from a combination of the oxigene of the acid with the lead. A portion of the lead is neverthelefs diſſolved; for if a ſufficient quantity of water be poured on the reſidue, a very cauſtic ſalt is obtained by evaporation, in tetrahedral priſms, ſoluble in eighteen times their weight of water. This ſulphate is decompoſed by fire, lime, the alkalis, &c.

Very hot ſulphureous acid, poured into a leaden veſſel, corrodes and deſtroys it inſtantly.

The concentrated nitric acid is readily decomposed upon lead, and converts it into a white oxide; but when the acid is weak it dissolves the metal, and forms cryſtals of an opake white, in the form of ſegments of a three-ſided priſm. I have ſpecimens of the nitrate of lead in my laboratory, which poſſeſs the form of truncated hexahedral priſms; three of the ſides being broader than the others, and exactly ſimilar to thoſe which Mr. De Fourcroy obtained by inſenſible evaporation.

This ſalt decrepitates in the fire, and is fuſed with a yellowiſh flame upon ignited coals. The oxide of lead becomes yellow, and is reduced into globules of metal. Sulphuric acid takes lead from the nitric acid.

The muriatic acid, aſſiſted by heat, oxides lead, and diſſolves a portion. This ſalt cryſtallizes in ſtriated hexahedral priſms.

This muriate is ſlightly deliqueſcent. Lime and alkalis decompoſe it.

The ſame acid poured on litharge decompoſes it inſtantly. Fifty or ſixty degrees of heat are produced. The ſolution affords fine octahedral cryſtals, of an opake white colour, a ſtyptic taſte, and of very conſiderable weight.

This ſalt decrepitates on the coals; and when the fire is increaſed, its water of cryſtallization

eſcapes, and it becomes converted into a maſs of a beautiful yellow colour.

Three parts of water, at fifteen degrees of temperature, diſſolve one part; and boiling water more than its weight.

The pure alkalis precipitate it in the form of a magma, which occaſions a kind of miraculus mundi.

The affinity of the muriatic acid with the oxide of lead is ſo ſtrong, that it is capable of decompoſing all its combinations. Minium or litharge decompoſes the muriate of ammoniac. The ſame oxides, triturated with marine ſalt, ſeparate the ſoda; and it is upon theſe facts that Mr. Turner and others have eſtabliſhed manufactories for procuring ſoda by the decompoſition of marine ſalt*.

The muriates of lead, calcined or fuſed, afford a pigment of a beautiful yellow colour. The ma-

* I do not hear that ſoda has been ſeparated from common ſalt by a method ſufficiently cheap for the purpoſes of commerce. It is univerſally underſtood that Mr. Turner's profits ariſe from the ſale of the combination of muriatic acid with the lead, which forms the yellow pigment known in London by the name of Patent Yellow. It may be produced ſimply by the fuſion of litharge and common ſalt; the alkali being volatilized, and driven off, if the fire be ſufficiently intenſe. T.

 nufactories

nufactories of ſoda have afforded a very conſiderable quantity, which is ſubſtituted inſtead of the fine Naples yellow.

4. The acetous acid corrodes lead; and affords a white oxide, known by the name of white lead.

To prepare this colour, the lead is melted, and caſt into plates about half a line in thickneſs, four or five inches wide, and two feet long. Theſe are rolled up in a ſpiral form, in ſuch a manner that the revolutions remain at the diſtance of half an inch from each other. They are then placed in pots, upon three points, which project from the inſide at about one third of the height. Malt vinegar is poured into theſe pots to the height of the bottom of the lead, and they are buried in dung beneath ſheds. A great number of theſe are diſpoſed beſide each other, and ſeveral ſtrata are formed. Care is taken to cover each pot with a plate of lead and boards. At the expiration of a month or ſix weeks they are taken out, and the white lead is ſeparated. This white calx is then ground in mills, and afterwards put into a vat, from which it is taken out to dry. The drying is performed in the ſhade, becauſe the ſun impairs the colour. For this purpoſe it is put into

 ſmall

ſmall conical earthen pots; and when ſufficiently dry it is wrapped in paper, and diſtributed for ſale.

Ceruſe does not differ from white lead, excepting that a more or leſs conſiderable quantity of chalk is mixed with it.

All the oxides of lead are ſoluble in vinegar. The ſolution of the acetate of lead, duly concentrated, cryſtallizes in efloreſcent tetrahedral priſms; and forms the ſalt of ſaturn, or ſugar of lead.

Cauſtic alkalis diſſolve the oxides of lead, and the metal may be precipitated by the addition of acids. When the alkaline ſolution is concentrated, the lead re-appears nearly in the metallic form, and the alkali is found to have acquired a faint and very peculiar taſte.

The uſes of lead in the arts are multifarious. It is uſed to make water pipes, boilers, coverings for the roofs of buildings, tea-cheſts, and other articles of package. It is rendered proper for theſe uſes, either by laminating it, or by cauſing it to flow out upon a bed of ſand well rammed and levelled, or upon the cloth called ticking.

It is likewiſe uſed to make bullets and ſmall ſhot. The bullets are caſt in moulds; but the ſmall ſhot is made in the following manner:—Lead is

 fuſed

fuſed with a ſmall quantity of arſenic, to render it more brittle; and when its temperature is ſuch as to admit of a card being plunged in it without burning, it is poured into a kind of cullender, pierced at the bottom with many holes, and containing lighted charcoal: this cullender is held over water; and the lead aſſumes a round form as it enters this liquid.

Lead is uſed in the tinning of copper veſſels. This is a pernicious fraud ſupported by cuſtom, and tolerated by the want of vigilance in the police. It is the more dangerous from the circumſtance that fats, oils, and vinegar corrode or diſſolve lead, which by that means becomes mixed with the aliments.

Lead ore is likewiſe uſed to glaze pottery. For this purpoſe galena is pulverized, and mixed with water. The veſſel intended to be glazed is dipped into this fluid, after having been expoſed to a firſt baking. It accordingly becomes covered with the galena; which, when expoſed to a violent heat, paſſes to the ſtate of glaſs, and forms a covering of the glaſs of lead over the whole ſurface. This proceſs is attended with the inconvenience of introducing a dangerous poiſon into our culinary veſſels, whoſe effects on the health of individuals cannot but be ſenſibly felt.

Oxided

Oxided lead enters into the compoſition of glaſſes, cryſtals, and enamels. It poſſeſſes the advantage of facilitating the fuſion, and giving the glaſs an unctuous feel, and a degree of ſoftneſs, which renders it capable of being cut and poliſhed.

White lead and ceruſe are uſed by painters. Theſe oxides poſſeſs the ſingular advantage of not being perceptibly altered by their mixture with oil; and form, by their whiteneſs and body, a baſis or receiver, which is very ſuitable for a variety of colours. The workmen who grind theſe colours are affected by them; and ſooner or later become ſubject to the painters colic, *colica pictorum.*

Litharge is at preſent uſed to decompoſe ſea ſalt; and the muriate of lead by fuſion forms a ſuperb yellow, very much employed in varniſh colours.

8. Ceruſe is likewiſe much uſed for drying up habitual moiſture of the ſkin, and for ſlight burns. It is applied to the ſkin in the form of powder, and there is no remedy more ſpeedy.

The ſalt of ſaturn, or ſugar of lead, is almoſt entirely uſed by the callico printers.

The vinegar of ſaturn, or the vegeto-mineral water of Mr. Goulard, is a very proper aſtringent in the conſequences or remains of venereal

disorders: it is likewise used to wash burns and ulcers, and to facilitate their cure.

This extract is likewise used to clarify liquors, and to deprive brandies of their colour; an evil practice which has been common for some years at Sette, though prohibited under heavy penalties.—The wine merchants avail themselves of this composition but too often, or of litharge, to render their sour wines sweet. This fraud was prodigiously common at Paris in the year 1750; and it was proved that, in the interval of three years, thirty thousand muids of vinegar had been thus sweetened, and sold for wine.

The oxides of lead are likewise used to harden oils, or to render them more drying. In this operation the oxigene of the oxide combines with the oil, and causes it to approach nearer to the nature of resins. There is likewise a solution of lead in oils, which serves as the basis of plasters.

CHAP. IX.

Concerning Tin.

TIN is a metal of a white colour, intermediate between that of lead and ſilver. It is very flexible, and produces a crackling noiſe when bended. No other metal poſſeſſes this property except zinc, in which it is infinitely leſs marked.

This metal is very ſoft, and the lighteſt of any of the entire metals. The ſpecific gravity of fuſed tin is 7,2914, according to Briſſon.

A cubic foot of this metal weighs about five hundred and ten pounds. It is very ductile under the hammer; and its tenacity is ſuch, that a wire of one tenth of an inch in diameter is capable of ſupporting forty-nine pounds eight ounces without breaking. Mr. De la Chenaye has cryſtallized tin after ſeveral repeated fuſions; he obtained by this means an aſſemblage of priſms united together ſideways.

Tin has been found in the metallic ſtate in the bowels of the earth. Mr. Sage poſſeſſes a ſpe-

cimen from the mines in Cornwall, and Mr. De Lisle likewise has one in his collection. This tin, so far from exhibiting any trace of fusion, has the external appearance of molybdena: it is easily broken; but the detached pieces may be flattened by the hammer.

Tin ore is either white or coloured.

1. The white tin ore, which has been often confounded with tungsten, crystallizes in octahedrons. Its texture is lamellated, and it frequently includes portions of reddish tin ore. That of Cornwall afforded Mr. Sage sixty-four pounds of tin in the quintal.

2. The coloured tin ore does not differ from the preceding, excepting that it contains iron, and sometimes cobalt. This ore usually has the form of irregular polyhedrons.

These ores afford carbonic acid by distillation when exposed to fire in a crucible. They decrepitate, lose somewhat of their colour, and become one-tenth less heavy.

Bergmann found sulphureous tin ore among the minerals he received from Siberia. He affirms that this ore was of a golden colour externally, resembling aurum musivum; and internally it presented a mass of radiated, white, brilliant, brittle crystals, which assumed changeable colours on exposure to the air.

To

To aſſay a tin ore, nothing more is neceſſary than to fuſe it in the midſt of the coals. Calcination in the open fire diſſipates much of the metal, according to the obſervation of Cramer.

In the working of tin ores, the mineral muſt be ſorted very exactly; after which it is to be pulverized, and waſhed upon tables covered with cloth. By agitation with a wiſp or broom, the gangue is ſuſpended or carried away by the water, and the tin ore remains alone.

The furnace made uſe of in Saxony for the fuſion of tin ore, is a variety of the blaſt-furnace, on the hearth of which is a groove to receive the melted metal, and convey it into a baſon; whence it is taken to be caſt in moulds of copper or of iron.

The tin ores of Cornwall are frequently mixed with copper, and arſenical pyrites. The quartz, which is its gangue, is very hard; and on this account the operation is begun by torrefaction of the ore before it is pulverized. After the ore is waſhed, a ſeparation of the magnetical iron is effected by means of loadſtones. The ore is uſually fuſed in the reverberatory furnace.

In Saxony, and in England, the ſcoriæ are three times fuſed to ſeparate the tin, after which they are pounded to ſeparate the laſt portions of metal.

metal. As the vein of tin in the mines of Cornwall is always mixed or accompanied with a vein of copper, the tin muſt contain this latter metal, however great the precautions which may be attended to in the working.

We are acquainted with three kinds of tin in commerce.

1. Pure tin, ſuch as that of Malacca, of Banca, and the ſoft tin of England. The tin of Malacca is caſt in moulds which give it the form of a quadrangular truncated pyramid, with a ſmall rim at its baſe. It is called, in France, *Etain en Chapeau*, or *en Ecritoire*. Each ingot weighs one pound.—The tin of Banca is in the form of oblong ingots, weighing from forty to forty-five pounds each.

2. The Engliſh tin, in large pigs, is caſt into ſticks of ten or twelve lines in diameter, and a foot and a half long.

3. The tin of the pewterers is alloyed with various metals. The law in France permits them to add copper and biſmuth; and they of their own authority add zinc, lead, and antimony.

Every kind of tin enters into fuſion with conſiderable facility, for it is the moſt fuſible of the metals. If it be kept in fuſion for a ſhort time, expoſed to the action of the air, the ſurface becomes wrinkled, and covered with a grey pelli-

pellicle. If this firſt covering be taken off, the tin appears with all its brilliancy; but ſoon becomes dull, and is oxided again. Tin gains one-tenth of its weight by this calcination. When the oxide is white, it is then called Putty. It is this oxide of tin which the makers of pewter ſpoons, who uſually travel over the country, call the Droſs of Tin. They are very careful to ſcum the metal as often as poſſible, to clear it of the droſs; and by this means they avoid giving the peaſant any more of his old pewter than that which they cannot contrive to take away from him. They are very well acquainted with the art of fuſing this pretended droſs into good tin, by heating it in contact with charcoal.

The putty of tin is uſed to poliſh hard bodies; and to render glaſs opake, which converts it into enamel. Tin takes fire by a violent heat, according to Geoffroy; and a white oxide ſublimes, while part of the tin is converted into a glaſs of an hyacinthine colour.

If tin be kept in fuſion in a lined crucible, and the ſurface be covered with a quantity of charcoal to prevent its calcination, the metal becomes whiter, more ſonorous, and harder, provided the fire be kept up for eight or ten hours.

Tin, and ſeveral other metals, may acquire a bril-

brilliancy they do not ufually poffefs, by pouring them out at the moment before they would congeal in the crucible. This treatment fecures them from the oxidation they fuffer in cooling, when they are poured out too hot; and by this method, which is very fimple, I have procured to tin and lead a degree of brilliancy which they would hardly be thought capable of exhibiting.

Tin, diftilled in clofe veffels, affords a white fublimate in the neck of the retort, which Margraff took for arfenic; but Meffrs. Bayen and Charlard have proved that it was not that fubftance.

The action of acids upon tin varies according to the degree of purity of the metal.

The fulphuric acid of commerce diffolves tin, by the affiftance of heat; but part of the acid is decompofed, and flies off in the form of very penetrating fulphureous acid. Water alone precipitates this oxided metal. Mr. Monnet has obtained cryftals by calcination, which refemble fine needles, interlaced among each other. The fulphuric acid diffolves the oxide of tin much better.

The nitric acid devours tin. The decompofition of this folvent is fo fpeedy, that the metal is feen to be precipitated, almoft inftantly, in a white oxide. If this acid be loaded with all

the

the tin it is capable of calcining, and the oxide be waſhed with a conſiderable quantity of diſtilled water, a ſalt may be obtained by evaporation, which detonates alone in a crucible well heated, and which burns with a white and thick flame, like that of phoſphorus. The nitrate of tin, diſtilled in a retort, ſwells up, boils, and fills the receiver with a white and thick vapour, which has the ſmell of nitric acid.

Mr. Baumé even pretends that the nitric acid does not diſſolve tin; but Kunckel, and the famous Rouelle, have maintained the contrary. Meſſrs. Bayen and Charlard diſſolved five grains in two gros of pure nitric acid, diluted with four gros of diſtilled water.

The muriatic acid diſſolves tin, whether cold or heated. During the effervеſcence, a very fetid gas is diſengaged. The ſolution is yellowiſh, and affords needle-form cryſtals by evaporation, which attract the humidity of the air. Mr. Baumé prepared this ſalt in the large way for the callico printers. Out of twelve pounds of tin, diſſolved in forty-eight pounds of acid, he had a reſidue of two ounces ſix gros of a grey and ſoluble powder, which Margraff had taken for arſenic. Mr. Baumé has obſerved that the cryſtals of the muriate of tin differ according to the ſtate of the acid. He obtained cryſtals,

cryſtals, ſimilar to thoſe of the ſulphate of ſoda, in needles, or in ſcales like thoſe of the acid of borax. Mr. Monnet aſſerts that he obtained, by the diſtillation of a muriate of tin, a fat matter, a true butter of tin, and a liquor reſembling that of Libavius.

The oxigenated muriatic acid diſſolves tin ſpeedily; and the ſalt which it produces, poſſeſſes all the characters of the ordinary muriate, according to Mr. De Fourcroy.

That which is known by the name of the Fuming Liquor of Libavius, appears to me to be a muriate of tin, in which the acid is in the ſtate of the oxigenated muriatic acid. To make this preparation, tin is amalgamated with one-fifth of mercury; and this amalgam in powder is mixed with an equal weight of corroſive ſublimate. The whole is then introduced into a retort, a receiver adapted, and diſtillation proceeded upon by a gentle heat. An inſipid liquor paſſes over firſt, which is followed by a ſudden eruption of white vapours, which condenſe into a tranſparent liquor, that emits a conſiderable quantity of vapours by mere expoſure to the air. The reſidue in the retort, for an analyſis of which we are indebted to Mr. Rouelle the younger, conſiſts of a ſlight lining in the neck of the retort, which contains a ſmall quantity

tity of the fuming liquor, ſome muriate of tin, muriate of mercury, and running mercury. The bottom of the veſſel contains an amalgam of tin and mercury; above which lies a muriate of tin of a grey white, ſolid and compact, and which may be volatilized by a ſtrong heat.

The nitro-muriatic acid diſſolves tin with vehemence: a violent heat is excited; and it frequently happens that a magma is obtained reſembling pitch, which becomes harder in proceſs of time. This happens when the very concentrated acid has diſſolved too much of the metal; and theſe inconveniences may be obviated by adding water in proportion as the ſolution proceeds.

The ſolution of tin which conſtitutes the compoſition for ſcarlet, is made with the common aqua fortis, prepared with ſaltpetre of the firſt boiling. This is a kind of nitro-muriatic acid, which unfortunately varies in its properties, according to the too variable proportions of muriate of ſoda and nitrate of pot-aſh. For this reaſon, the dyers are continually making complaints either that the aqua fortis precipitates, which happens when it contains too ſmall a quantity of muriatic acid; or that it affords an obſcure colour, which depends on an exceſs of the ſame acid. The firſt inconvenience is remedied

medied by diſſolving ſea ſalt, or ſal ammoniac, in the aqua fortis; and the ſecond by adding ſaltpetre.

The moſt accurate proportions to make a good ſolvent for tin, are, two parts of nitric acid, and one of muriatic acid.

Tin is likewiſe ſoluble in the vegetable acids. Mr. Schultz, in his Diſſertation *De Morte in Olla*, has demonſtrated the ſolubility of this metal in acids. Vinegar corrodes it by a gentle heat, according to the experiments of Margraff.

Moſt of the tin in commerce is alloyed with various metals. That of England contains copper and arſenic artificially, according to Geoffroy; and naturally, according to the Baron Dietrich, Sage, &c. The tin of the plumbers or pewterers, called Pewter, contains ſeveral metals. The ordonnance in France permits them to add a ſmall quantity of copper and biſmuth. The firſt metal renders it hard; and the latter reſtores the brightneſs which would elſe have been impaired by the copper, and renders it more ſonorous. The pewterers take upon themſelves to add antimony, zinc, and lead; the antimony hardens it, the zinc renders it whiter, and the lead diminiſhes its value. It is a deſirable circumſtance to poſſeſs the means of aſcertaining the nature and proportions of theſe

theſe alloys. We are indebted for the following proceſſes to Meſſrs. Bayen and Charlard.

A. When tin contains arſenic, the ſolution in the muriatic acid exhibits a black powder which conſiſts of arſenic ſeparated from the tin. This method is capable of rendering the two thouſand and forty-ſecond part of alloy perceptible.

B. If the tin contains copper, the muriatic acid, which attacks tin with facility, precipitates the copper in the form of a grey powder, provided there be no exceſs of acid, and the ſolution be made without heat. The copper is likewiſe precipitated by a plate of tin immerſed in the ſolution.

C. Biſmuth is ſhewn by the ſame proceſs as the copper.

D. To aſcertain the mixture of lead, the nitric acid muſt be uſed, which corrodes the tin, and diſſolves the lead.

The pewterers have two methods of aſſaying this metal.

1. The aſſay of the ſtone, which conſiſts in pouring it into a hemiſpherical cavity made in a calcareous ſtone, and terminating in a channel or groove. The workman attentively obſerves the phenomena of its cooling; and from theſe circumſtances, as well as from the crack-

ling or noiſe which the tail of the aſſay affords when bended, he judges of the purity of the metal.

2. The aſſay by the ball conſiſts merely in a compariſon of the weight of pure tin with that of adulterated or alloyed tin, poured into the ſame mould.

It cannot but be immediately perceived that theſe methods are very imperfect.

The various metals which are prejudicial to health, are not added to the tin in a ſufficiently great proportion to produce any dangerous effects. It ſeems that Margraaf was deceived by ſome foreign circumſtance, when he affirmed that the tin of Morlaix contains thirty-ſix grains of arſenic in the half ounce; for this quantity is more than ſufficient to render the metal as brittle as zinc. Meſſrs. Bayen and Charlard found no arſenic in the tin of Banca and of Malacca. The tin of England never contains more than three-fourths of a grain of arſenic in the ounce of metal: and ſuppoſing this to be the miximum, the daily uſe of tin cannot be dangerous; ſince a plate in which arſenic exiſted in this proportion, loſt no more than three grains per month by conſtant uſe, which amounts to the five thouſand ſeven hundred and ſixtieth part of a grain of arſenic loſt daily. The experiments which

which these two skilful chemists have made upon animals, by mixing arsenic in larger proportions with tin, are sufficient to remove every apprehension concerning the use of this metal.

The lead alone may be productive of dangerous consequences, because the pewterers add it in a very considerable proportion.

The combination of tin with sulphur forms aurum musivum, or mosaic gold. The process for making it which has best succeeded in my hands, is that described by the Marquis de Bullion. It consists in forming an amalgam of eight ounces of tin and eight ounces of mercury. For this purpose, a copper mortar is heated, and mercury poured into it; and when it has acquired a certain degree of heat, the melted tin is poured in, and the mixture agitated and triturated till cold. Six ounces of sulphur, and four ounces of sal ammoniac, are then mixed; and the whole put into a mattrass, which is to be placed on a sand bath, and heated to such a degree as to cause a faint ignition in the bottom of the mattrass. The fire must be kept up for three hours. The aurum musivum thus obtained is usually beautiful: but if, instead of placing the mattrass on the sand, it be immediately exposed upon the coals, and strongly and suddenly heated, the mixture will take fire,

and a sublimate will be formed in the neck of the vessel, which consists of the most beautiful aurum musivum. I have obtained it by this process of a dazzling colour, in large hexagonal scales.

The mercury and the sal ammoniac are not in strictness necessary to the production of aurum musivum. Eight ounces of tin dissolved in the muriatic acid, precipitated by the carbonate of soda, and mixed with four ounces of sulphur, produced the Marquis of Bullion a fine aurum musivum: but this is not capable of increasing the effects of the electrical machine; which proves that the composition owes its virtue in that respect to the mercury it contains in the proportion of six to one, when prepared in the former process. This preparation is used to give a beautiful colour to bronze, and to increase the effects of the electrical machine by rubbing the cushions.

The Baron Kienmayer has described the following amalgam, composed of two parts of mercury, one of zinc, and one of tin:—The zinc and the tin are to be fused, and mixed together with the mercury; and the mixture agitated in a wooden box, internally rubbed with chalk. The mass is then to be reduced to a fine powder; and employed in that state, or mixed with

greaſe. The effect of this amalgam is ſurprizing; for by this means the power of electrical machines is inconceivably augmented.

The amalgam of tin is capable of cryſtallization. Mr. Sage's proceſs conſiſts in pouring two ounces of melted tin into a pound of mercury. After having introduced this mixture into a retort, he urged it by a violent fire for five hours on the ſand bath. No mercury was diſengaged; but the tin was found in a cryſtallized ſtate above the mercury, which had not entered into combination. The lower part of this amalgam is compoſed of grey brilliant cryſtals in ſquare plates, thin towards their edges, leaving polygonal cavities between each. Every ounce of tin retains in its cryſtallization three ounces of mercury.

The amalgam of tin is uſed to ſilver looking-glaſſes. For this purpoſe, a leaf of tin is ſpread out upon a table of the ſize of the glaſs, mercury is poured upon it, and ſpread about with a bruſh. This being done, a larger quantity of mercury is poured upon the tin, ſo as to form a covering of more than one line in thickneſs. The glaſs is ſlided upon this covering, by preſenting one of its edges; taking care at the ſame time that its ſurface ſhall be beneath the level of the mercury, in order that the impurities

 which

which might hinder a perfect contact may be driven before it. The plate of glass is then loaded with weights equally distributed over its whole surface; by which means all the excess of mercury is pressed out, and flows away through channels made in the edges of the table. The air being driven out from between the amalgam of tin and the glass by this strong compression, serves greatly to render the amalgam adherent. Several days are required to elapse before it be sufficiently dry to admit of removing the glass.

Tin alloyed with copper forms bronze, or bell-metal. Seven parts of bismuth, five of lead, and three of tin, form an alloy which liquefies in boiling water.

CHAP. X.

Concerning Iron.

IRON is the most generally diffused metal in nature. Almost every mineral substance of this globe is coloured with it; and its various alterations produce that truly astonishing variety

riety of colours, which are comprehended between the blue and the deepeſt red. This metal likewiſe exiſts in the vegetable kingdom, where it conſtitutes an almoſt inſeparable principle. It even appears to be one of the products of organization, or vegetation; for it is found in vegetables which are ſupported merely by air or water. It is indeed contrary to ſound philoſophy to ſuppoſe that all the iron with which earths are impregnated, muſt ariſe from the wearing of ploughſhares: for, not to mention that the plough has not paſſed every where, we ſee iron daily formed in vegetables. There is no reaſon to fear that the metal ſhould on this account become too abundant; becauſe it is continually deſtroyed by paſſing to the ſtate of oxide.

If, on the other hand, we caſt our attention towards the infinite number of uſes to which this metal is applied in ſociety, we ſhall perceive that it is perhaps the moſt eſſential to be known, becauſe it is the moſt diffuſed, the moſt uſeful, and the moſt employed.

This metal is of a white livid colour, inclining to grey, obedient to the magnet, and gives fire with quartz; which laſt circumſtance is attributed to the fuſion and rapid combuſtion of

particles of the metal detached by the ſtroke. It is the lighteſt of all metals except tin. One cubic foot of forged iron weighs five hundred and forty-five pounds. The ſpecific gravity of fuſed iron is 7,2070.—See Briſſon.

Iron is very hard, ſuſceptible of a fine poliſh, and very difficult of fuſion. It may be drawn into very fine wire, of which the ſtrings of the harpſichord are made. It becomes hard by hammering, without heat; but when aſſiſted by heat, it may be hammered into every imaginable form.

Iron is univerſally diſperſed; but, by common conſent, thoſe places, or matrices, in which the iron is ſufficiently abundant to be wrought with profit, are called Iron Mines, or Ores.

Iron is found native, without mixture, in ſeveral places. We ſhall not here mention thoſe ridiculous aſſertions, which have no other merit than that of having been authorized by the ſuffrages of certain celebrated men.—" Albertus Magnus decidiſſe cœlo, imbre, maſſam ferri centum librarum. *Petermannus*, magnâ tempeſtate, cum projectu multorum lapidum, cœlo molem ferri decidiſſe, quæ in longitudine ſexdecim, in latitudine quindecim, in craſſitie duos, pedes habuerit:" that is, of the weight of

of forty-eight thouſand pounds, and containing four hundred and eighty cubic feet.—Becher Supplem. in Phyſ. Subter. cap. iii. p. 599.

We are indebted to Lehman for a deſcription of a piece of native iron poſſeſſed by Margraaf, which came from Eibenſtock in Saxony. The grain was diſtinguiſhable on both ſides.

Henckel poſſeſſed a ſmall piece incruſted with a yellow earth; and the cabinet of the Royal School of Mines poſſeſſes one which is covered with ſpathoſe iron ore. Adanſon and Wallerius affirm that it is found in Senegal; and Rouelle received a piece from thence which was very malleable. Simon Pallas ſpeaks of a maſs of native iron found near the great river Jeneſei in Siberia. This iron is very ſpongy, very pure, perfectly flexible, and proper to be formed into inſtruments by a moderate fire. It is naturally incruſted with a kind of varniſh which preſerves it from ruſt.

Mr. Macquart doubts the legitimacy of the native iron, deſcribed by Pallas: he thinks that it may be conſidered as fuſed iron. Mr. De Morveau does not believe in the exiſtence of native iron.

Though ſome doubts may be raiſed concerning the legitimacy of theſe pieces, and there may be reaſons to conſider ſome of them as conſe-

quences

quences of the action of fire, we cannot however refuse to admit of the existence of native iron, after the depositions, facts, and attestations which present themselves on all sides in support of this truth.

Iron, slowly cooled, crystallizes in octahedrons almost always implanted one in the other. We are indebted to Mr. Grignon for this observation. I am in possession of a piece of iron entirely covered with small tetrahedral, flat, and truncated pyramids. Some of the pyramids have a base of one line in breadth. It comes from the frontiers of the Comté de Foix. This iron is very seldom found unaltered by foreign admixtures; but I think we may consider all the iron ores which are attracted by the magnet, as containing the native metal, dispersed in some gangue: and we shall attend to these species before we treat of the oxides and martial salts.

ARTICLE I.

Concerning Iron Ores which are attracted by the Magnet.

1. The octahedral iron ore.—This ore has the form of octahedrons, isolated, and dispersed in a gangue of schistus, or calcareous stone. The

The cryſtals are grey, very regular in their form, and ſtrongly bedded in the ſtone. Their ſize is from half a line to ſix or ſeven in diameter. Corſica and Sweden afford this kind.

Mr. Sage obſerves that octahedral cryſtals of iron are ſometimes found in the fineſt white marble of Carara. The black ferruginous ſand which accompanies the hyacinths in the brook of Expailly, is an octahedral iron ore, obedient to the magnet.

2. Iron ore in ſmall plates or ſcales.—The ſmall plates or ſcales which are attracted by the magnet, and are found in moſt rivers which contain gold, are an iron ore, nearly in the metallic ſtate. This ſand forms the reſidue which is left after the precious metal has been taken up by amalgamation. It is mixed with fragments of quartz, garnets, &c. I found a large quantity in the ſand of the river of Ceze: it was alſo ſent me from the neighbourhood of Nantz. I have received ſome likewiſe from Spain; and this ſand has afforded me certain phenomena which appear to entitle it to a particular rank among the metals. Acids diſſolve it by the aſſiſtance of heat; and always without effervеſcence, or the diſengagement of gas. It communicates the ſame colour to the nitro-muriatic acid as platina

platina does. It is indecompoſable by heat, either in the open fire, or in open veſſels. I have endeavoured to reduce it by all the known fluxes, but in vain. It precipitates in the flux, mixes with it, and recovers its form and magnetic virtue by pulverizing the maſs. It poſſeſſes ſeveral characters of the ſiderotete, or phoſphate of iron.

3. Iron diſperſed in ſtones renders them obedient to the magnet. The ophites, the ſerpentines, the micas, the pot-ſtones, and ſeveral marbles, are in this ſituation. Iron diſſeminated in a gangue of quartz, or very hard jaſper, forms emery, which on account of its hardneſs is uſed to grind and poliſh glaſs. It comes to us from Jerſey and Guernſey, where it is plentifully found.

The magnet itſelf is nothing elſe but the iron we ſpeak of, modifiedin ſuch a manner as to afford a paſſage to the magnetic fluid, and to exhibit the known phenomena. The magnet is ſometimes found in a regular form. Mr. Sage affirms that he poſſeſſes a ſmall piece of magnet from St. Domingo, on which octahedrons are diſtinguiſhable. We likewiſe read, in the General Hiſtory of Voyages, that at twenty leagues from Solikamſkai in Siberia magnets are found of a

cubical

cubical form and greenifh colour, of a lively brilliant appearance, which are reducible into glittering fcales by pulverizing.

The magnet varies in its quantity of metal. Thofe of Sweden and Siberia are very rich in iron; but the magnetic force is not in proportion to the iron they contain.

There is reafon to think that the magnetic agent is a modification of the electric power. 1. Iron which remains a long time in an elevated pofition becomes magnetic. 2. Inftruments of iron ftruck with lightning are ufually magnetized. 3. Two pieces of iron may be magnetized by rubbing them againft each other in the fame direction. 4. Black iron ores are found in Sweden which are attracted by the magnet, and whofe metallic particles are fometimes fo weakly connected together that they are reducible into powder. We have feveral fpecies of thefe ores in Languedoc.

This fpecies is in general very rich, and affords near eighty pounds of iron per quintal.

5. Iron appears to exift in the metallic ftate in fome other fpecies, fuch as the fpecular iron ore. But the metallic ftate is lefs evident and characteriftic, the metallic qualities being more changed; and thefe ores are lefs attracted by the magnet.

Theſe iron ores frequently exhibit metallic plates of a brilliancy equal to that of ſteel, and unalterable in the air. The ore of Mont d'Or, that of Framont in the principality of Salm, and thoſe of the mountains of Voſges, have afforded us very curious ſpecimens. Theſe plates are ſometimes hexagonal, formed by two hexahedral pyramids truncated near their baſe.

The ſpecular iron ore of Framont afforded Mr. Sage fifty-two pounds of iron in the quintal: the iron is very ductile, and acquires much fibre.

The celebrated iron ore of the iſland of Elbe is of this kind, but it has not the plated form. Its cryſtals are lenticular, with brilliant facets, which are dodecahedrons with triangular planes. Theſe beautiful groupes of cryſtals are ſometimes ſhaded with the moſt lively colours. White clay, rock cryſtal, cupreous pyrites, &c. are found among them.

The Lucqueſe work this ore in the Catalan method, by ſtratifying charcoal and the ore, one layer over the other. The fire is kept up by good bellows; and when all the coal is conſumed, the iron is found collected together in a maſs, which is carried to the hammer.

The eiſenman is a ſcaly ſpecular ore. When it is rubbed, brilliant particles are detached from

it;

it; which has caufed the miners of Dauphiny to give it the name of Luifard.

The eifenram is an iron ore of a brilliant red colour, which contains plumbago and iron.

ARTICLE II.

Concerning Sulphureous Iron Ores, or the Sulphures of Iron.

The union or combination of iron and fulphur forms the fulphureous iron ore, martial pyrites, fulphure of iron, &c. Thefe fulphures are very abundant, and are evidently formed by the decompofition of vegetables. I have feveral times found pieces of wood buried in the earth perfectly incrufted with pyrites. The effect of fubterraneous fires is owing only to the mixture of thefe fulphures with the remains of vegetables. Thofe fpecies of coal which effloresce in the air, owe their decompofition only to the pyrites with which they are penetrated. It is likewife to the decompofition of the pyrites that we muft refer the heat of moft mineral waters. The fulphure of iron fometimes cryftallizes in cubes, and often in octahedrons. The union of a number of octahedral

hedral pyramids with their points towards a common centre, forms the globular pyrites.

When the ſulphur is diſſipated, it ſometimes happens that the pyrites loſes neither its form nor its weight. It then becomes brown, is attracted by the magnet, and is called the Brown or Hepatic Iron Ore.—See De Liſle.

But the decompoſition of pyrites moſt commonly produces the ſulphuric acid, which ſeizes the iron, diſſolves it, and forms an effloreſcence on the ſurface. Advantage has even been taken of this property of the pyrites to eſtabliſh manufactories of ſulphate of iron, or copperas. The two valuable eſtabliſhments which have been made of this kind, in the vicinity of Alais, work certain ſtrata of a hard ponderous pyrites. Theſe are formed into heaps upon areas, where the ground is ſlightly inclined. The effloreſcence is accelerated by watering the pyrites, groſsly broken, with water. This fluid diſſolves all the ſalt which is formed, and carries it into reſervoirs, where the ſolution ſuffers all the foreign matters it may contain to ſubſide. It is left at reſt in theſe reſervoirs, in which the ſun produces a ſlight concentration of the fluid; and the concluding evaporation is made in leaden cauldrons, with the addition of old iron, to ſaturate the acid with as much of that metal

as poſſible. The cryſtallization is performed in baſons, in which pieces of wood are diſpoſed to aſſiſt the formation of cryſtals. Theſe two manufactories in Languedoc are capable, in their preſent ſtate, of furniſhing upwards of forty thouſand quintals of copperas, if the demand required it.

In order to facilitate the vitriolization, it is neceſſary to give acceſs to the air, becauſe the concurrence of this element is neceſſary to form the ſulphuric acid.

The ſulphate of iron cryſtallizes in rhomboids.

It effloreſces in the air, and gradually loſes its fine green colour by the diſſipation of its water of cryſtallization.

If the ſulphate of iron be expoſed to heat, it liquefies, boils, becomes thick, and is reduced into powder. This powder, mixed with pulverized nut galls, forms a dry ink, which ſeveral perſons ſell as a ſecret, and which requires only the addition of water to render it fit for uſe.

The ſame powder, urged by a ſtronger heat, ſuffers its acid to eſcape; after which there remains only a martial earth, or metallic oxide, known by the name of Colcothar.

I attribute the formation of all the yellow or red earths, commonly called ochres, to a ſimilar decom-

decompoſition of the pyrites. The heat produced by the decompoſition of the pyrites has determined the reſpective colours of theſe earths; and they may be cauſed to paſs artificially through theſe various ſhades, by treating them with various degrees of fire. I have diſcovered, in the dioceſe of Uzes, banks of ochre of ſuch an uncommon fineneſs, and ſo very pure, that calcination converts it into a brown red, ſuperior to every thing before known in trade. The manufactory which has been eſtabliſhed under my care, has acquired all the celebrity which the ſuperiority of its products could not but neceſſarily afford it. My experiments on theſe ochres, and the advantages which they may afford to the arts, may be ſeen in the work which I have publiſhed on this ſubject, printed for Didot the elder, at Paris.

I likewiſe found at Mas-Dieu, near Alais, a ſtratum of red ochre of ſo beautiful a colour, that it could ſcarcely be imitated.

ARTICLE III.

Concerning the Spathoſe Iron Ores, or Carbonates of Iron.

The carbonic acid is ſometimes combined with iron in ores; and the reſemblance between this iron and ſpar, has procured it the name of the Spathoſe Iron Ore.

The formation of this ore appears to be owing to the mutual decompoſition of the carbonates of lime, and the ſulphates of iron. A ſolution of copperas, in which calcareous ſpar was ſuffered to remain, produced this ore, according to the experiments of Mr. Sage.

Bergmann obtained from the ores of this kind, which he analyſed, thirty-eight ounces of the oxide of iron, twenty-four ounces of the oxide of manganeſe, and fifty ounces of calcareous earth. It appears therefore that this ore contains two metals united by a calcareous cement, which cryſtallizes always in its own form, as we find in the lapis calaminaris, the calcareous grit, &c.

The ſpathoſe iron ores are wrought at Caſcaſtel, in the dioceſe of Narbonne, at Bendorf

on the banks of the Rhine, at Eiſenartz in Styria, &c.

ARTICLE IV.

Concerning the Bog Ores of Iron, or Argillaceous Iron Ores.

Theſe ores conſiſt merely of a martial oxide, in a ſtate of greater or leſs purity, mixed with earthy ſubſtances of the nature of clays.

They appear to have been depoſited by water; and are uſually diſpoſed in ſtrata, which are frequently marked out, and as it were ſeparated, into ſmall priſms, whoſe formation ariſes ſimply from the ſhrinking of the clay.

1. The eagle-ſtone, or ætites, ought to be ranked among the bog ores of iron. They are geodes of a round or oval form, having a hard external covering, while the cavity includes a detached nodule; and the noiſe produced by ſhaking one of theſe ſtones, ariſes from the nodule being at liberty to move within the ſtone.

The name of eagle-ſtone has ariſen from a notion, formerly entertained, that eagles placed it in their neſts to facilitate the laying of their eggs; and wonderful powers of rendering labours

bours ſafe and eaſy, were attributed to it in the times of ſuperſtition.

2. We are acquainted with an iron ore in round pieces, reſembling bullets, of ſeveral lines in diameter, which ought to be conſidered as a variety of the preceding. An ore of this kind was begun to be wrought at Fontanez, near Sommieres; and we find a conſiderable quantity of theſe metallic globules among our red earths in the neighbourhood of Montpellier.

3. The pureſt oxide of iron, worn and carried along by waters, and afterwards depoſited, forms ſtrata of various appearances and colours. Theſe are called hæmatites.

The colours ariſe from the various degrees of alteration in the oxide. They vary from yellow to the deepeſt red. The red hæmatites is uſed in the arts to burniſh gold or ſilver. It is cut into long pieces, which when poliſhed are known by the name of burniſhers. This bloodſtone is ſometimes ſoft enough to be uſed inſtead of a crayon for drawing.

Its figure is likewiſe ſubject to prodigious variation. It often appears as if compoſed of ſmall priſms applied one againſt the other, in which caſe it is called the fibrous hæmatites. In other ſpecimens it is tuberculated. It is very frequently found in compact irregular maſſes,

 ſuch

ſuch as thoſe of the ores of the county of Foix. This muſt naturally exhibit the ſame variety of forms as the calcareous ſtalactites, becauſe its mode of formation is nearly the ſame.

ARTICLE V.

Concerning Native Pruſſian Blue, or the Pruſſiate of Iron.

Beccer ſpeaks of a blue earth found at Turinge. Henckel informs us that a blue martial earth is found at Schneeburg and at Eibenſtock. Cronſtedt has deſcribed a native Pruſſian blue: Mr. Sage found it in the turf of Picardy. It is likewiſe found in Scotland, in Siberia, &c. and I poſſeſs a ſulphure of iron in a ſtate of decompoſition, which exhibits a true pruſſiate of iron upon one of its ſurfaces.

ARTICLE VI.

Concerning Plumbago, or the Carbure of Iron.

The name of plumbago is at preſent confined to that ſhining ſubſtance of a blackiſh blue colour, which is uſed to make the pencils called black-

black-lead pencils. It has a greafy feel, exhibits a tuberculated fracture, foils the hands, and leaves a black trace upon paper.

Plumbago is found in many places: that of commerce is brought to us from Germany. We receive it likewife from Spain, from America, and from England. It is alfo found in France. This mineral is almoft always difpofed in feparate maffes in the bowels of the earth; and it is probably on account of this form, that the ancients denoted it by the words Glebæ Plumbariæ.

The plumbago of England differs from the other fpecimens in its texture, which is much finer, and of a greater degree of brilliancy. The Englifh do not take a larger quantity out of the mine than the market demands, in which they are careful to keep up the price.

The moft plentiful mine is in the county of Cumberland.

The plumbago of Spain is always accompanied with pyrites, which effloresce on the furface of the pieces; either in fmall cryftals, fimilar to thofe of the fulphate of iron; or in a kind of filky vegetation, analogous to that of plume alum. It is dug up in the neighbourhood of the town of Ronda, at the diftance of four leagues from the Mediterranean fea. It is the

worſt kind which comes to market, and is uſed only to give a ſhining black colour to iron utenſils.

The American plumbago, which Mr. Woulfe procured for Mr. Pelletier, breaks eaſily, and exhibits ſmall quartzoſe grains in its internal part, as well as ſlight traces of a whitiſh clay. It is found in ſeparate maſſes; and its texture appears to conſiſt of the union of an infinity of ſmall ſcaly parts, which at firſt ſight might cauſe it to be taken for molybdena.

France likewiſe poſſeſſes plumbago, and the chevalier Lamanon obſerved it in Upper Provence. The mine is ſituated near Col de Bleoux. The black lead is found between two ſtrata of clay, not more than a few lines in thickneſs. It forms a ſtratum of four inches thick; or rather the ſtratum conſiſts of ſeparate maſſes, which are ſometimes ſeveral feet in length. It is accompanied by a vein of pyrites. The inhabitants of Bleoux ſell this product at Marſeilles at about fifteen livres per quintal. Mr. De la Peyrouſe found plumbago with tourmalines in the county of Foix, and Mr. Darcet brought it from the Pyrenean Mountains.

Plumbago is indeſtructible by heat without the preſence of air. Mr. Pelletier expoſed it

to

to diſtillation, in the pneumato-chemical apparatus, by a violent fire during ſix hours, without the plumbago having loſt weight, or ſuffered any other change. He expoſed two hundred grains in a well-cloſed porcelain crucible to the fire of the manufactory at Seves, and it loſt only ten grains. But when it is calcined with the concurrence of air, it then burns, and leaves but a ſmall quantity of reſidue. Meſſrs. Quiſt, Gahn, and Hielm obſerved that one hundred grains, treated under a muffle in a ſhallow veſſel, left only ten grains of oxide of iron. Mr. Fabroni diſſipated the whole of a portion of plumbago expoſed under the muffle. This calcination is a ſlow combuſtion, which is facilitated by cauſing the matter to preſent a large ſurface, and agitating it from time to time.

If one part of plumbago, and two of very cauſtic dry alkali, be heated in a retort with the pneumato-chemical apparatus, the alkali becomes effervеſcent, hydrogenous gas is obtained, and the plumbago diſappears. This beautiful experiment proves that the ſmall quantity of water contained in the ſalt is decompoſed; and that its oxigene, by combining with the carbone of the plumbago, forms the carbonic acid. The experiment publiſhed by

Scheele

Scheele has been repeated and confirmed by Mr. Pelletier.

The ſulphuric acid does not act upon plumbago, according to Scheele. Mr. Pelletier has obſerved that one hundred grains of plumbago, and four ounces of oil of vitriol, being digeſted in the cold for ſeveral months, the acid acquired a green colour, and the property of congealing by a very ſlight degree of cold. The ſulphuric acid diſtilled from plumbago, paſſes to the ſtate of the ſulphureous acid; at the ſame time that carbonic acid is obtained, and an oxide of iron is left in the retort.

The nitric acid has no action upon plumbago unleſs it be impure. Eight ounces of nitric acid, diſtilled from half a gros of purified plumbago, neither altered its ſhining appearance, nor deprived it of its unctuous feel.

The muriatic acid diſſolves the iron and the clay which contaminate native plumbago. Meſſrs. Berthollet and Scheele availed themſelves of this method to purify it. The liquor being decanted after digeſtion upon the plumbago, the reſidue is then waſhed, and ſubmitted to diſtillation to ſeparate the ſulphur. The muriatic acid alone has no action upon plumbago, but the oxigenated muriatic acid diſſolves it; the reſult being a true combuſtion effected by

by the oxigene of the acid, and the carbone of the plumbago.

If ten parts of the nitrate of pot-aſh be fuſed in a crucible, and one part of plumbago be thrown thereon by a little at a time, the ſalt will deflagrate, and the plumbago will be deſtroyed. The matter which remains in the crucible conſiſts of very effervеſcent alkali, and a ſmall portion of martial ochre.

If plumbago be diſtilled with muriate of ammoniac, the muriate ſublimes, coloured by the iron.

All theſe facts prove that plumbago is a peculiar combuſtible ſubſtance, a true charcoal combined with a martial baſis. Plumbago is more common than is imagined. The brilliant charcoal of certain vegetable ſubſtances, more eſpecially when formed by diſtillation in cloſe veſſels, poſſeſſes all the characters of plumbago. The charcoal of animal ſubſtances poſſeſſes characters ſtill more peculiarly reſembling it. Like it they are difficult to incinerate, they leave the ſame impreſſion on the hands and upon paper; they likewiſe contain iron, and become converted into carbonic acid by combuſtion. When animal ſubſtances are diſtilled by a ſtrong fire, a very fine powder ſublimes, which attaches itſelf to the inner part of the neck of the

retort.

retort. This fubftance may be made into excellent black lead pencils, as I myfelf have proved.

Carbone may be formed in the earth by the decompofition of wood together with pyrites; but the origin of plumbago appears to me to be principally owing to the ligneous, and truly indecompofable, part of the wood, which refifts the deftructive action of water in its decompofition of vegetable fubftances. This ligneous fubftance, difengaged from the other principles, muft form peculiar depofitions and ftrata; and Mr. Fabroni has affured me that the formation of plumbago in water is a common phenomenon, of which he had feveral times been a witnefs. This chemift, by his letter of the thirtieth of January 1787, informs me that, in the dominions of the king of Naples, there are wells dug exprefsly for the purpofe of collecting an acidulous water, at the bottom of which wells a quantity of plumbago is collected every fix months.

He fuppofes that the black mud which is found beneath the pavement of Paris is plumbago formed in the humid way.

There are likewife diftricts in Tufcany where plumbago is formed in the humid way.

This

This ſubſtance is of conſiderable uſe in the arts. It has been at all times applied to the purpoſe of making pencils, the moſt eſteemed of which are thoſe which come from England. They are made at Keſwick in the county of Cumberland. The piece of plumbago is ſawed into very thin plates. The edge of one of theſe plates is fitted into a groove ſtruck in a wooden cylinder; and the thin plate of plumbago is then cut off in ſuch a manner that the cavity of the ſmall cylinder remains perfectly filled.

The duſt of plumbago is uſed to lubricate certain inſtruments; and it is likewiſe made into pencils of an inferior quality, by kneading it up with mucilage, or by fuſing it with ſulphur. The fraud may eaſily be diſcovered by the aſſiſtance of fire, which burns the ſulphur; or by means of water, which diſſolves the mucilage.

Plumbago is likewiſe uſed to defend iron from ruſt. The hearths and plates of chimneys, and other ſimilar utenſils, which appear very bright, owe their colour to plumbago. Homberg has communicated a proceſs, in the year 1699, in which plumbago is applied to this uſe. Eight pounds of hogs-lard are melted with a ſmall quantity of water, with the addition of four ounces of camphor. When this laſt is fuſed,

the mixture is taken from the fire; and, while it is yet hot, a ſmall quantity of plumbago is added, to give it a leaden colour. When this is to be applied, the utenſils muſt be heated to ſuch a degree, that the hand can ſcarcely be applied to them. In this ſtate the compoſition muſt be rubbed on them, and afterwards wiped when the piece is dry.

Thoſe who prepare ſmall ſhot, make uſe of black lead to poliſh and glaze it: the ſhot is rolled or agitated together with a quantity of plumbago. Plumbago is likewiſe uſed to make razor ſtrops. When kneaded up with clay, it forms excellent crucibles, which we receive from Paſſaw in Saxony. One part of plumbago, three of argillaceous earth, and a ſmall quantity of cows dung very finely chopped, form an excellent lute for retorts. Mr. Pelletier has uſed it with great advantage. This lute is exceedingly refractory; and the glaſs will melt without the covering changing its form.

To make the aſſay of an iron ore, I find the following flux very advantageous:—I mix four hundred grains of calcined borax, forty grains of ſlacked lime, two hundred grains of nitrate, and two hundred of the ore to be aſſayed. I pulverize this mixture, and place it in a lined crucible, which I cover. The heat of a forge

furnace is ſufficient to effect the reduction. In the ſpace of half an hour, the button of metal is found depoſited at the bottom of the vitrified flux.

The proceſs for working iron mines varies according to the nature of the ore. The metal is ſometimes ſo little altered, and ſo abundant, that nothing more is neceſſary than to mix it with the coal, and fuſe it. This ſimple and œconomical proceſs forms the baſis of the Catalan method, which may be employed in treating the ſpathoſe iron ores, thoſe of Elbe, the hæmatites, and other rich and pure ores. But it cannot be applied to ſuch as contain much foreign matter capable of becoming converted into ſlag. For this reaſon, the experiments made in the county of Foix on the ores of various countries, and various qualities, have not ſucceeded. On this head, the work of Mr. De la Peyrouſe, and the Memoirs of the Baron de Dietrich, may be conſulted.

The furnaces in which iron is fuſed, are from twelve to eighteen feet in height. Their internal cavity has the form of two four-ſided pyramids joined baſe to baſe. The only flux added to the ore is the calcareous ſtone, named (by the French) *caſtine*, if the ore be argillaceous; but, if the gangue be calcareous, the workmen employ

employ argillaceous earth, which is named *herbue.*

The furnace is charged at the upper part; and the fire is excited by bellows, or hydraulic machines. The ore melts as it paſſes through the coal; and is collected at the bottom, where it is maintained in a liquid ſtate. At the end of every eight hours it is ſuffered to flow out into the mould, or hollow channel made in the ſand.

Crude iron, caſt in ſuitable moulds, forms chimney-backs, pots, cauldrons, pipes, and an infinity of utenſils or vaſes, which could not be obtained without difficulty by forging the iron. The works which are eſtabliſhed at Creuſot in Burgundy ſurpaſs every thing which can be deſired in this ſpecies of induſtry.

This firſt product is called Caſt or Crude Iron. It is brittle; but may be rendered ductile by heating it again, and hammering it. For this purpoſe the pig iron is fuſed again, and ſtirred while in the ſtate of fuſion: after which it is carried to the forge hammer. By this treatment the iron becomes ductile, aſſumes a fibrous texture, and is formed into ſquare or flat bars for the purpoſes of trade.

Iron is likewiſe capable of a degree of ſuperiority, which is given to it by placing it in con-

tact

tact with coaly substances, and softening it to such a degree that these may penetrate into its texture. It is then known by the name of Steel. We are indebted to Mr. Jars for very interesting accounts of the steel manufactories in England. The manufactory established at Amboise is not inferior to those of England, as was ascertained by comparative experiments made upon the products of the several manufactories, at Luxemburg, on Friday the 7th of September, 1786.

We may therefore divide the different states of iron into cast or crude iron, iron properly so called, and steel. It is clear that these three states are nothing more than modifications of each other; but the circumstances on which they depend, and the principle which establishes their difference, were till lately unknown.

The celebrated Bergmann has given an analysis of the various states of iron, and has drawn up the following table:

	Cast Iron.	Steel.	Iron.
Inflammable Air	40	48	50
Plumbago -	2 - 20	0 - 50	0 - 12
Manganese -	15 - 25	15 - 25	15 - 25
Siliceous Earth	2 - 2·5	0 - 60	0 - 175
Iron -	80 - 30	83 - 65	84 - 45

This celebrated chemiſt has confirmed by his reſults the concluſion of Reaumur, who always conſidered ſteel as an intermediate ſtate between crude and malleable iron.

We are indebted to three French chemiſts, Meſſrs. Monge, Vandermonde, and Berthollet, for a quantity of much more accurate information reſpecting all theſe ſtates.

We may conſider iron ores as natural mixtures of iron, oxigene, and various foreign ſubſtances. When an ore is wrought, the object of the operator is to clear the iron of all theſe matters. To effect this ſeparation, the ore is thrown into the ſmelting furnaces, with different proportions of charcoal. Theſe matters are heated together until they arrive at the hotteſt part where the mixture falls; and, after ſuffering the ſtrong action of the fire, is precipitated in fuſion, and forms a fluid maſs at the bottom of the furnace. The earths and ſtones, nearly in a vitrified ſtate, float above the fluid; and the oxigene, being partly driven out, remains likewiſe in a greater or leſs quantity in the crude iron. The crude iron is either white, or grey, or black. In our enquiries concerning the cauſe of theſe three kinds of iron, and their qualities, we can refer them only to the proportions

of

of foreign principles contained in the crude iron. Theſe principles are carbone and oxigene.

1. Crude iron contains carbone. The ladles which are uſed to agitate, take up, and pour out this melted metal, become covered with a coating of plumbago, which contains nine-tenths of carbone; and caſt iron, ſtrongly heated in contact with the coal, ſuffers a part to eſcape or exſude from its ſurface when it is ſlowly cooled. Crude iron emits ſparks when it is heated; the acids which diſſolve it always leave a reſidue which is purely carbonaceous. The hydrogenous gas, which is obtained by treating theſe irons with acids, always affords the carbonic acid by combuſtion.

2. Crude iron contains oxigene. Several mineralogiſts attribute the fragility and brilliancy of crude iron to its ſtill containing iron in the ſtate of oxide. This opinion, which is generally adopted, ſuppoſes the exiſtence of oxigene. Crude iron, urged by a violent heat in cloſe veſſels, affords the carbonic acid, and paſſes to the ſtate of ſoft iron; becauſe its oxigene then unites to the carbonaceous principle, and conſtitutes the carbonic acid, which exhales, and clears the crude iron from the two principles which altered its quality.

Oxigene and carbone exiſt therefore in crude

iron, but they may exiſt in three different ſtates—1. A large quantity of carbone, and a ſmall quantity of oxigene. 2. An exact proportion between theſe two principles. 3. Much oxigene, and a ſmall quantity of carbone.—Now we find theſe three ſtates in the three kinds of crude iron which we have diſtinguiſhed, as is proved by analyſis; and, as we may judge by the ſecondary proceſſes, to correct theſe imperfections, or to convert crude iron to the malleable ſtate.

1. In the firſt caſe, that iron which contains an exceſs of carbone is agitated or ſtirred as it flows out. It is kept a long time expoſed to the action of the bellows, and the ſmalleſt poſſible quantity of charcoal is made uſe of. We ſee that in this proceſs the propereſt methods are uſed to facilitate the combuſtion of this exceſs of the carbonaceous principle.

2. In the ſecond caſe, that kind of iron in which the principles exiſt in accurate proportions, requires only the action of heat to unite and volatilize the two foreign principles. The crude iron is put into a ſtate of ebullition by the diſengagement of the acid which is formed, and exhales.

3. In the third kind, or that which contains oxigene in exceſs, the bellows are urged leſs violent-

violently; and the metal is penetrated with coal, in order to combine with the oxigene. Here therefore we ſee theory and practice go together. The former explains the uſual manipulations, and affords us principles in caſes wherein experiment too frequently fails.

Steel is a kind of iron which contains carbone only; and its exiſtence may be proved by all the experiments which have been mentioned as demonſtrations that crude iron contains it.

Carbone may be given to iron—1. In the fuſion of the ore. 2. Or, afterwards, by the cementation of iron with coaly ſubſtances.

1. In ſome parts of Hungary, and in the county of Foix, iron ores are wrought which contain the metal nearly in the diſengaged ſtate; and the caſt iron, when duly hammered, affords iron and ſteel in a greater or leſs quantity, according to the management of the fire, the quantity of air afforded by the tuyere, the quantity of coal made uſe of, and the nature of the ore. In this operation, the iron being ſcarcely at all calcined in the ore, becomes charged with coaly matter only, and the reſult is ſteel.

2. If the coaly principle be combined with iron in a ductile ſtate, and deprived of all foreign matter, the combination being effected by

cementation or otherwiſe, the iron will paſs to the ſtate of ſteel; and the qualities of this ſteel will vary according to the proportions of carbone. The purity of the iron, and the care which is taken to avoid the oxidation of the metal, eſtabliſh the various kinds of ſteel which are met with in commerce.

The nature and the principles of ſteel being once admitted and eſtabliſhed, the following facts will explain themſelves.

1. Since ſteel contains no foreign principle but carbone, it is not ſurpriſing that it remains unchanged by a violent heat in cloſe veſſels.

2. Steel, repeatedly heated, and expoſed while hot to a current of air, loſes its properties, and paſſes again to the ſtate of ſoft iron.

3. Steel kept plunged for a time in crude iron in which oxigene predominates, becomes itſelf converted into ſoft iron.

4. Soft iron kept for a time plunged in crude iron, wherein carbone predominates, becomes converted into ſteel.

5. Iron, by paſſing to the ſtate of ſteel, increaſes in weight one hundred and ſeventieth part.

Ductile iron would be a very ſoft metal, if it were cleared of all foreign ſubſtances.

From all theſe facts we may conclude—

1. That

1. That crude iron is a mixture of iron, carbone, and oxigene. 2. That the products of crude iron are white, grey, or black, according to the proportions of oxigene and carbone which it contains. 3. That the ſteel of cementation is merely a mixture of iron and carbone. 4. That ſteel which is over-cemented, is an iron containing too large a quantity of carbone. 5. That iron would be a very ſoft metal, if it were not mixed with a greater or leſs quantity of oxigene and carbone.

Forged iron is diſtinguiſhed into ſoft iron, and eager or brittle iron, by us (the French) called Rouvrain. This laſt has a coarſer grain than the other: it is divided into red ſhort iron, and cold ſhort iron. The cauſe of this phenomenon is known: it ariſes from a phoſphate of iron, which was diſcovered by Bergmann. This celebrated chemiſt conſtantly obſerved a precipitate to be formed in the ſolutions of cold ſhort iron in the ſulphuric acid. It was a white powder, which he called Siderite, and at firſt ſuppoſed to be a peculiar metal; but Mr. Meyer of Stetin has proved that it is a true phoſphate of iron.

Soft iron does not afford it. All the irons of Champagne afford about a dram, or gros, in the pound of iron.

In order to obtain ſiderite, it is neceſſary that the ſolution ſhould be ſaturated by a gentle heat on the ſand bath. If the ſolution be made too quickly, the ſiderite is then mixed with ochre, which alters its purity and whiteneſs.

A precipitate is formed, which takes place ſo much the more ſpeedily, as the ſolution is more diluted with water each time after filtration. The precipitate is formed in the firſt three or four days; a ſecond is obtained towards the ſixth day; and that which afterwards falls down is mixed with ochre.

Siderite may likewiſe be obtained by diſſolving iron in the nitric acid, and evaporation to dryneſs. The iron is oxided by this firſt operation. More nitric acid being poured on this reſidue, diſſolves only the ſiderite, without touching the oxide of iron. A ſecond evaporation muſt then be made; and the reſidue muſt be diluted with water, to evaporate the laſt portions of nitric acid: and that which remains is ſiderite. It is ſoluble in the ſulphuric, nitric, and muriatic acids, from which it may be precipitated by pouring into the ſolution as much alkali as is neceſſary to ſaturate the acid ſolvent. If the alkali be added in exceſs, ochre is then precipitated; and the reſult is a phoſphate, and a ſalt ariſing from the union of the acid

made

made uſe of and the alkali which has ſerved for the precipitation.

The fixed and volatile alkalis, and lime water, decompoſe ſiderite. It is likewiſe decompoſed by projecting it upon fuſed nitre.

When it has been precipitated by ammoniac, cryſtals may be obtained by evaporation, which when treated with powder of charcoal afford phoſphorus. The ochreous precipitate affords iron by reduction; it is therefore a combination of the phoſphoric acid and iron. Every ſolution of iron is precipitated in the form of ſiderite by the phoſphoric acid.

The effect of the tempering of iron likewiſe deſerves the attention of the chemiſt. I am of opinion that the hardneſs and brilliancy which iron acquires by this operation, ariſes from its integrant parts, which are ſeparated by the heat, being kept and left at a certain diſtance from each other by the ſudden cold, which drives out the heat, without bringing the conſtituent principles of the maſs together. The iron is then more brittle, becauſe the affinity of aggregation is leſs.

Iron is eaſily oxided. A bar of iron which is heated a long time in the forge furnace, becomes oxided at its ſurface; and the coatings of metal which

which paſs to the ſtate of oxide, are ſeparated from the maſs in the form of ſcales. The moſt degraded and the moſt altered metal, in the ſtate when it is no longer attracted by the magnet, forms an oxide of a reddiſh brown colour, known by the name of Aſtringent Saffron of Mars, or the Brown Oxide of Iron.

The colour of this oxide varies according to its degree of oxidation. It is yellow, poppy-colour, or red; and is eaſily reduced into a black powder, when heated with coaly matters.

The combined action of air and water conſtitutes a martial oxide, known by the name of Aperitive Saffron of Mars. This compoſition is produced by the combination of oxigenous gas and carbonic gas with the iron. The expoſition of the iron to a humid atmoſphere ruſts it ſpeedily, and cauſes it to paſs to the ſtate of aperitive ſaffron of Mars. This preparation is a true carbonate of iron.

Water likewiſe acts upon iron. If iron filings be put into this liquid, and be agitated from time to time, the iron becomes divided, and blackens; and by decanting the turbid water, a black powder is depoſited, which is called the Martial Æthiops of Lemery, or the Black Oxide of Iron. It is a commencement of calcina-

tion effected by the air contained in the water; but more especially by the decomposition of the water itself.

The fixed and volatile alkalis, in the fluid state, being digested upon iron, oxide a slight portion, which falls down in the form of æthiops.

All acids act more or less upon iron.

1. The concentrated sulphuric acid is decomposed by boiling upon this metal. If the mixture be distilled to dryness, the retort is found to contain sublimed sulphur, and a white mass, partly soluble in water, but incapable of crystallization.

But if the diluted sulphuric acid be poured upon iron, a considerable effervescence arises in consequence of the disengagement of hydrogenous gas. In this operation, the water is decomposed, its oxigene is employed to calcine the metal, while the hydrogene is disengaged; and the acid acts upon and dissolves the metal without being decomposed. This solution, when concentrated by evaporation, affords the sulphate of iron, which we have already treated of.

2. The nitric acid is decomposed rapidly upon iron. The solution is of a red brown colour, and suffers the oxide of iron to fall down at the expi-

expiration of a certain time. If new iron be plunged in this ſolution, the acid diſſolves it, and lets fall the oxide which it held in ſolution.

If the ſolutions be concentrated, martial ochre of a red brown colour falls down. If the concentration be carried ſtill further, a reddiſh jelly is formed, which is partially ſoluble in water.

Iron, precipitated from its ſolution by the carbonate of pot-aſh, is eaſily diſſolved by the ſuperabundant alkali, and forms the martial alkaline tincture of Stahl.

Mr. Maret has propoſed to precipitate the iron by the cauſtic alkali, to make the æthiops immediately. Mr. Darcet, in rendering an account of the proceſs of Mr. Maret to the Royal Society of Medicine, has propoſed that of Mr. Croharé, which conſiſts in boiling upon the iron water acidulated with the muriatic acid.

Mr. De Fourcroy made a courſe of experiments upon the martial precipitates, which throws much light upon the cauſes of the aſtoniſhing varieties obſerved in them. He has proved that the whole depends either on the nature of the acid, or the manner of operating at the time of making theſe precipitates, or the quality of the precipitant.

3. The diluted muriatic acid attacks iron with vehemence. Hydrogenous gas is diſengaged,

gaged, which arifes from the decompofition of the water. If the folution be concentrated, and left to cool when it is of the thicknefs of fyrup, a magma is formed; thin, flattened cryftals are perceived, which are very deliquefcent. The muriate of iron, diftilled in a retort by the Duke d'Ayen, exhibited very fingular phenomena. The firft product was an acid phlegm. At a ftronger heat, a non-deliquefcent muriate of iron fublimed, at the fame time that very tranfparent cryftals rofe to the roof of the retort, in the form of the blades of razors, which decompofed the light in the fame manner as the beft prifms. At the bottom of the retort there remained a ftyptic deliquefcent falt, of a brilliant colour, and a foliated appearance, which exactly refembled the large plated talc, improperly called Mufcovy Glafs. This laft falt, expofed to a violent heat, afforded a fublimate more aftonifhing than the former products. It was an opake fubftance, truly metallic, which exhibited fections of hexahedral prifms, polifhed like fteel. It was iron reduced, and fublimed.

4. It was long fince known that iron is precipitated from its folutions by vegetable aftringent fubftances; and the black dyes, and the fabrication of ink, are founded on this known fact.

fact. But it was not till lately that an acid has been proved to exiſt in theſe ſubſtances, which combined with the iron, and which may be obtained from all theſe aſtringent vegetables, either by ſimple diſtillation, or by mere digeſtion in cold water. The moſt ſimple proceſs is the following:

Infuſe one pound of powder of nut-galls in $2\frac{3}{4}$ pints of pure water. Leave the mixture together for four days, frequently ſhaking the infuſion. Then filter, and leave the fluid in a veſſel ſimply covered with blotting paper. The liquid becomes covered with a thick pellicle of mouldineſs, and a precipitate falls down in proportion as the infuſion evaporates. Theſe precipitates collected, and diſſolved in boiling water, form a liquor of a brown yellow colour, which, evaporated by a gentle heat, depoſits— 1. A precipitate which reſembles fine ſand. 2. Cryſtals diſpoſed in the form of a ſtar. This ſalt is grey; and it is impoſſible to obtain it of a whiter colour by any repetition of ſolutions and cryſtallizations.

It is an acid which effervesces with chalk, and reddens the infuſion of turnſole.

Half an ounce of this ſalt is ſoluble in an ounce and a half of boiling water, or twelve ounces of cold water.

Boiling

Boiling ſpirit of wine diſſolves its own weight of this acid; but cold ſpirit diſſolves only one-fourth.

This ſalt is inflammable in the fire. It melts, and leaves a coal of difficult incineration.

When this acid is diſtilled in a retort, it becomes at firſt fluid, gives out an acid phlegm, but no oil; and, towards the end, a white ſublimate riſes, which attaches itſelf to the neck of the retort, and remains fluid as long as it is hot, but afterwards cryſtallizes. Much coal is found in the retort. The ſublimate has nearly the taſte and ſmell of acid of benzoin, is as ſoluble in water as in ſpirit of wine, reddens the infuſion of turnſole, and precipitates metallic ſolutions with their different colours, and iron black.

The ſolution of the ſalt of the nut-gall, poured into a ſolution of gold, renders it of a dark green; and precipitates a brown powder, which is gold revived.

The ſolution of ſilver becomes brown; and at length depoſits a grey powder, which is revived ſilver.

The ſolution of mercury is precipitated of a yellow orange colour.

The ſolution of copper affords a brown precipitate.

The ſolution of iron becomes black.

The

The ſolution of the acetite of lead is precipitated white.

This ſalt is changed into the oxalic acid, if the nitric acid be diſtilled from it.

The baſis of ink conſiſts of a ſolution of iron by the gallic acid. To make good ink, take one pound of nut-galls, ſix ounces of gum arabic, and ſix ounces of green copperas, with four pints of common water. The nut-galls muſt be bruiſed, and infuſed for four hours without boiling. The pounded gum muſt be firſt added, and ſuffered to diſſolve; and, laſtly, the copperas, which immediately converts the fluid to a black colour. Lewis, of the Royal Society of London, made many reſearches on this ſubject; but he always returns to the forementioned ſubſtances. Powdered ſugar is ſometimes added, to render the ink ſhining.

5. The vegetable-acid likewiſe diſſolves iron with facility. It is this which holds the metal ſuſpended in vegetables; and it may be precipitated from wine in the form of æthiops, by the means of alkalis.

Cream of tartar, or the acidulous tartrite of pot-aſh, likewiſe diſſolves iron; and the various degrees of concentration of this ſolution forms the ſoluble martial tartar, the aperitive extract of Mars, and the balls of Nancy.

7. The

7. The solution of iron, by the oxalic acid, affords prismatic crystals of a greenish yellow colour, and a somewhat astringent taste, soluble in water, and efflorescing by heat.

8. Iron, dissolved by the prussic acid, forms Prussian blue, or the prussiate of iron.

A singular mistake gave rise to the discovery of this substance. Diesbach, a chemist of Berlin, being desirous of precipitating a decoction of cochineal with fixed alkali, borrowed of Dippel an alkali upon which he had several times distilled animal oil; and as the decoction of the cochineal contained sulphate of iron, the liquor immediately afforded a beautiful blue. The experiment being repeated, was followed with similar results; and this colour became an object of commerce, under the name of Prussian Blue.

Prussian blue was announced in the Memoirs of the Academy of Berlin in the year 1710, but without any account of the process, which was kept a secret until other chemists discovered it. The process was rendered public in the year 1724, in the Philosophical Transactions, by Woodward; who declared that he had received it from one of his friends in Germany.

To make Prussian blue, four ounces of alkali are mixed with the same weight of dried bul-

 locks

locks blood, and the mixture exposed in a crucible, which is covered in order to stifle the flame; the fire is kept up until the mixture is converted into a red-hot coal. This charcoal is thrown into water, which is afterwards filtered, and concentrated by evaporation. The liquor is known by the name of the Phlogisticated Alkali. On the other hand, two ounces of the sulphate of iron and four ounces of the sulphate of alumine are dissolved in a pint of water. The two solutions are mixed, and a blueish deposition falls down, which is rendered still more intensely blue by washing it with muriatic acid.

Such is the process used in chemical laboratories; but in the works in the large way another method is followed. Equal parts of the raspings of horns, clippings of skins, or other animal substances, are taken, and converted into charcoal. Ten pounds of this coal are mixed with thirty pounds of pot-ash, and the mixture is calcined in an iron vessel. After twelve hours ignition, the mixture acquires the form of a soft paste, which is poured out into vessels of water. The water is then filtered; and the solution mixed with another, consisting of three parts of alum, and one of sulphate of iron.

I have likewise made Prussian blue by calcining and burning in the same vessel equal

parts

parts of the ſhavings of horns and tartar. I received the animal oil and the ammoniac, afforded by the calcination of theſe ſubſtances, in large caſks, which communicated with each other, and formed an apparatus after the manner of Woulfe.

It has likewiſe been obſerved that the tips of thyme, the ſun-flower, and ſeveral other vegetable ſubſtances, when treated with alkali, communicate to it, in a certain degree, the property of precipitating iron of a blue colour.

Much reaſoning has been exhibited on the etiology of this phenomenon. Meſſrs. Brown and Geoffroy conſidered Pruſſian blue as the phlogiſton of iron, developed in the lixivium of blood. The abbé Menon imagined that the colour of iron was blue, and that the phlogiſticated alkali precipitated it in its natural colour.

Mr. Macquer refuted the opinion of his predeceſſors in the year 1752; and propoſed a ſyſtem, in which he conſiders Pruſſian blue as iron ſuperſaturated with phlogiſton. This ſkilful chemiſt proved that the blue is not ſoluble in any reſpect in acids; and that the alkalis are capable of diſſolving the colouring matter of the Pruſſian blue, and of becoming ſaturated with it to ſuch a degree as to be no longer capable of effervеſcing.

Mr. Sage affirmed that the iron was ſaturated with the phoſphoric acid; and the celebrated Bergmann likewiſe ſuſpected the exiſtence of ſome animal acid, as is proved by his notes on the leſſons of chemiſtry of Scheffer. But it was reſerved to the celebrated Scheele to convert theſe ſuſpicions into certainty.

He has proved that the lixivium of blood, expoſed for a certain time to the air, loſes the property of precipitating iron of a blue colour; and he has ſhewn that this circumſtance depends on the carbonic acid of the atmoſphere, which diſengages the colouring part. By adding a ſmall quantity of ſulphate of iron to this lixivium, it is no longer changed in conſequence of its remaining in the carbonic acid. By boiling this lixivium upon an oxide of iron, it is likewiſe no longer capable of change in the carbonic acid. The iron has therefore the property of fixing and retaining the colouring principle; but it is neceſſary that it ſhould not be in the ſtate of oxide.

Pruſſian blue, treated in the way of diſtillation with the ſulphuric acid, permits a fluid to eſcape that holds the pruſſic acid in ſolution, which may be precipitated upon iron.

The proceſſes of Scheele, to obtain this acid in a ſtate of purity, conſiſt in putting two ounces of

of pulverized Pruſſian blue into a glaſs cucurbit, with one ounce of red precipitate, and ſix ounces of water. This mixture is to be boiled for ſome minutes, continually ſtirring it. It then aſſumes a yellow colour inclining to green. The fluid being filtered, two ounces of boiling water are to be thrown on the reſidue. This liquor is a pruſſiate of mercury, which cannot be decompoſed either by alkalis or acids. The ſolution is then poured into a bottle, in which an ounce of newly-made filings of iron is put: three gros of concentrated ſulphuric acid are to be added, and the whole agitated ſtrongly for ſeveral minutes. The mixture becomes perfectly black by the reduction of the mercury; the liquor loſes its mercurial taſte, and exhibits that of the colouring lixivium. After ſuffering it to ſtand at reſt for a time, it is decanted, put into a retort, and diſtilled by a gentle fire. The colouring principle paſſes firſt, becauſe more volatile than water. The operation muſt be put an end to, as ſoon as one quarter of the liquor has paſſed over. As this product contains a ſmall quantity of ſulphuric acid, it may be cleared of it by re-diſtilling it from pulverized chalk by a very gentle fire. The pruſſic acid then comes over in a ſtate of the greateſt purity. Scheele recommends that the veſſels be well luted,

luted, becauſe the acid would otherwiſe eſcape, on account of its great levity. It is even of advantage to put a ſmall quantity of water into the receivers, to abſorb the acid; and it would likewiſe be very proper to ſurround them with pounded ice.

This acid has a particular ſmell, which is not diſagreeable; and its taſte is ſweet.

It does not redden blue paper; but renders the ſolutions of ſoap and of the ſulphure of alkali turbid. Mr. Weſtrumb pretends that the pruſſic acid is the ſame as the phoſphoric; for he obtained ſiderite from Pruſſian blue, and formed animal earth by mixing the lixivium of blood with a ſolution of calcareous earth.

The ſolution of iron in the pruſſic acid affords Pruſſian blue. We are indebted to Mr. Berthollet for a very intereſting ſeries of experiments upon the pruſſic acid, and its combinations.

The oxide of iron is capable of exiſting in two different ſtates in combination with the pruſſic acid. If the oxide predominates, the combination is yellowiſh; but if its proportion be leſs, the product is Pruſſian blue. All the acids are capable of diſſolving the portion or ſurplus of oxide which conſtitutes the difference between the firſt and ſecond combination.

The

The prussiate of pot-ash contains oxide of iron. If an acid be poured in, this oxide is dissolved, and is precipitated by double affinity in the form of Prussian blue. The prussiate of pot-ash made by a gentle heat, afterwards evaporated to dryness, then re-dissolved, and filtered, no longer affords the blue upon the addition of acids. It crystallizes in square plates with their edges cut slantways, forming octahedrons, whose two opposite pyramids are truncated. This solution of the prussiate of pot-ash, when mixed with the sulphuric acid, deposits Prussian blue, if it be exposed to the solar light, or to a strong heat. In these processes the prussiate of alkali may be entirely decomposed; the prussiate of iron, when precipitated by the action of the alkaline prussiate, carries down with it a notable proportion of alkali, of which it may be cleared by washings, which contain the alkaline prussiate. It is the same with regard to precipitations by the prussiates of lime and ammoniac.

The prussiate of mercury crystallizes in tetrahedral prisms, terminating in quadrangular pyramids, whose planes answer to the angles of the prisms. Iron in its metallic state decomposes the prussiate of mercury, and deprives it both of its oxigene and its acid. The oxide of mercury like-

wise decomposes the prussiate of iron, and seizes its acid. The prussiate of mercury is but imperfectly decomposed by the sulphuric and muriatic acids. These acids form trisules, or triple salts, with it. The precipitate of the nitrate of barytes by the prussic acid, is not the compound which Bergmann supposed it to be, but is merely a trisule.

The prussic acid readily precipitates alumine from its nitric solution; the alumine nevertheless yields its prussic acid to iron.

The oxigenated muriatic acid, when mixed with the prussic acid, is again converted to the state of common muriatic acid: the prussic acid assumes a more lively smell, becomes more volatile, is deprived of its affinity to alkalis and lime; it precipitates iron of a green colour; and the green becomes blue if the precipitates be exposed to light, or if it be treated with the sulphureous acid.

The prussic acid, impregnated with the oxigenated muriatic acid, and exposed to light, assumes the smell of an aromatic oil, is collected at the bottom of the water in the form of an oil which is not inflammable, and rises in vapour by a gentle heat. By repeating this process it may be totally decomposed; and then this species of oil becomes concrete, and is reduced into crystals.

The

The acid appears to have undergone a partial combuſtion in this operation; at leaſt the light and the ſulphureous acid do not reſtore it but by depriving it of oxigene. The oxigenated pruſſic acid, mixed with lime or a fixed alkali, becomes totally decompoſed. Volatile alkali is diſengaged; and if the alkali was very cauſtic, ſuch as the alcohol of pot-aſh, it becomes effervescent.

The pruſſic acid of Scheele is only decompoſed in part by this proceſs; whence Mr. Berthollet concludes that it is compoſed of hydrogene, nitrogene, and carbone.

Theſe experiments do not prove that oxigene exiſts in this acid. The water affords that which enters into the carbonic acid, produced by the diſtillation of the pruſſic acid. Pruſſian blue takes fire more eaſily than ſulphur, and detonates ſtrongly with the oxigenated muriate of pot-aſh. The pruſſiate of mercury detonates ſtill more ſtrongly with the nitrate of mercury. The gas of theſe detonations has not yet been collected. The pruſſic acid, combined with alkali and the oxide of iron, cannot be ſeparated by any acid without intervention of heat or light; and when it is diſengaged, it is no longer capable of ſeparating iron from the weakeſt acid, unleſs it be in the way of double affinity. Mr. Ber-

Berthollet thinks that the elastic state of this acid diminishes this affinity; and that it is necessary, in order that it may easily enter into combination, that it should have lost some of its specific heat. It is this which renders the oxigenated acid so feeble.

Prussian blue afforded me, by distillation, in the ounce, one gros twenty-four grains of ammoniac, thirty-six grains of the carbonate of ammoniac, four gros twelve grains of oxide of iron, or alumine, and one hundred and sixty-four inches of hydrogenous gas burning with a blue flame.

The ammoniac comes over in combination with a small quantity of the colouring principle, which it takes up, and holds in solution: the sulphuric acid renders this visible.

Ammoniac heated upon Prussian blue decomposes it, by seizing the colouring matter.

Lime-water digested upon Prussian blue dissolves the colouring principle by the assistance of a gentle heat; the combination is rapid, and the water acquires a yellow colour. By filtration, the liquor passes of a fine bright yellow, no longer converts syrup of violets to a green, and is no longer precipitated by the carbonic acid. It appears to be completely neutralized, and affords an exceedingly fine blue, when poured

poured into a ſolution of the ſulphate of iron. The pruſſiate of lime has been propoſed, by Meſſrs. Fourcroy and Scheele, as the moſt accurate means of aſcertaining the preſence of iron in any mineral water.

The pure fixed alkalis immediately diſcolour Pruſſian blue in the cold. This combination produces heat; and the pure alkalis ought to be preferred to the carbonates of alkali in experiments of this nature.

Magneſia likewiſe ſeizes the colouring matter of Pruſſian blue; but much more weakly than lime-water.

A mixture of equal parts of ſteel filings and nitrate of pot-aſh, thrown into a crucible ſtrongly ignited, detonates at the end of a certain time, with the diſengagement of a conſiderable quantity of very bright ſparks. The reſidue, when waſhed and filtered, affords an oxide of iron of a yellowiſh colour, known by the name of Zwelfer's Saffron of Mars.

Iron decompoſes the muriate of ammoniac very well. Two gros of ſteel filings, and one gros of this ſalt, afforded Mr. Bucquet, by diſtillation in the pneumato-chemical apparatus over mercury, fifty-four cubic inches of an aëriform

form fluid; half of which was alkaline gas, and the other half hydrogenous gas.

This decompoſition is founded on the ſtrong action of the muriatic acid on iron.

One pound of the muriate of ammoniac in powder, and one ounce of ſteel filings, ſublimed together, form the martial flowers, or Ens Martis. Theſe flowers conſiſt merely of the muriate of ammoniac, coloured, and rendered yellow by an oxide of iron.

The oxide of iron decompoſes the muriate of ammoniac much better. This is an effect of double affinity. The ammoniac which riſes is ſometimes efferveſcent.

A mixture of good filings of ſteel and ſulphur, moiſtened with a ſmall quantity of water, becomes heated in the courſe of ſeveral hours. The water is decompoſed, the iron ruſts, the ſulphur is converted into acid, the hydrogenous gas of the water exhales, and the heat is ſometimes ſufficient to ſet the mixture on fire. This phenomenon conſtitutes the volcano of Lemery.

There is the ſtrongeſt analogy both in the phenomena and effects of the inflammation of this volcano, and the decompoſition of pyrites.

Sulphur combines eaſily with iron by fuſion, and then forms a true martial pyrites.

Iron may be alloyed with ſeveral metallic ſub-

fubftances; but the only alloy which is ufed in the arts is that which it contracts with tin, to form white iron, or tin plates.

To form the tin plates (commonly known by the name of Tin in England), the fofteft iron is chofen, which is reduced into very thin plates. Care is taken to polifh or clean the furface very well; and this is done in feveral ways. The pieces are rubbed with fand-ftone, and afterwards kept for three times twenty-four hours in water, acidulated by the fermentation of malt, turning them from time to time. They are afterwards cleaned, dried, and are then ready for tinning. Sal ammoniac is likewife ufed in fome manufactories. For this purpofe the plates are difpofed in a chamber, in which a certain quantity of fal ammoniac is volatilized. The falt forms a covering over the whole furface of every plate, and poffeffes the double advantage of clearing it from ruft, and affording the coaly principle neceffary to prevent the calcination of the metal.

When the iron is well cleared, the plates are plunged vertically into a bath of tin, whofe furface is covered with pitch, or tallow. They are turned in the bath; and when taken out they are wiped with faw-duft, or bran.

The ufes of iron are fo very extenfive, that

there

there are few arts which can be practiſed without it. It is with juſtice conſidered as the ſoul of all the arts. Some of its ores are uſed in their native ſtate; ſuch as the hæmatites, which is made into burniſhers.

The ſulphate of iron is the baſis of all black colours, inks, &c.

The ochres are uſed by painters, under the name of Umber; and the brown red has the moſt extended uſe. With us (in France) it is applied to give a colour to brick pavements, to paint our doors and windows, to ſmear our caſks, and to ſecure them from decay and inſects in ſea voyages.

Caſt iron is uſed to make boilers, chimney-grates, hearths, pots, &c. The inſtruments of agriculture are made of this metal: ſteel is uſed not only as ſteel; but its hardneſs renders it proper to cut and work the other metals.

The magnetical property of iron has led to the diſcovery of the mariner's compaſs; and this metal, if it were productive of no other advantage to mankind, would on that account be entitled to their greateſt attention.

Pruſſian blue is an agreeable colour, greatly eſteemed, and much uſed.

Iron likewiſe furniſhes the art of medicine with remedies. It is the only metal which is

not noxious; and it has ſuch an analogy with our organs, that it appears to conſtitute one of the elements of the human frame. Its effects in general conſiſt in ſtrengthening the ſtomach; and it appears to poſſeſs the property of paſſing in the circulation under the form of æthiops. The valuable experiments of Mr. Menghini, publiſhed in the Memoirs of the Inſtitute of Bologna, have proved that the blood of perſons who take martial remedies is thicker, and contains more iron. Mr. Lorry obſerved that the urine of a ſick perſon, to whom he adminiſtered iron in a ſtate of extreme diviſion, was manifeſtly coloured with the nut-gall.

C H. A P. XI.

Concerning Copper.

COPPER is a reddiſh metal, hard, elaſtic, ſonorous, and affording a diſagreeable ſmell by friction. Its taſte is ſtyptic, and nauſeous. One cubic foot of copper weighs five hundred and forty-five pounds. The ſpecific

gravity

gravity of caſt copper not hammered is 7,7880.
—Briſſon.

The alchemiſts diſtinguiſhed this metal by the name of Venus, on account of the facility with which it unites and is alloyed with other metals.

It may be reduced into very thin leaves, and drawn into very fine wire. The tenacity of this metal is ſuch, that a wire of one tenth of an inch in diameter, is capable of ſupporting a weight of two hundred and ninety-nine pounds four ounces, without breaking.

This metal is capable of affecting a regular form. The abbé Mongez obſerved it in ſolid quadrangular pyramids, ſometimes inſerted into each other.

Copper is found in various forms in the bowels of the earth.

1. Native copper.—This copper exiſts ſometimes in leaves in a gangue of quartz. It is likewiſe found in compact maſſes at Japan. There is one of theſe pieces in the royal cabinet, which weighs ten or twelve pounds.

Native copper is uſually diſſeminated in a browniſh martial earth, ſuſceptible of a poliſh. When this ore is rubbed with a flint, the traces appear of a beautiful copper-colour. Ores of this kind are found at Kaumſdorf in Thuringia.
—Sage, Analyſe Chimique, t. iii. p. 205.

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We have likewiſe found native copper at Saint Sauveur. It has the form of nodules reſembling ſtalactites. Moſt of the native coppers appear to be formed by cementation, or by the precipitation of this metal diſſolved in an acid, and thrown down by martial ſalts.

Mr. Sage thinks that this metal may likewiſe be precipitated from its ſolutions by phoſphorus. To effect, ſays he, the precipitation of copper by phoſphorus, twelve grains of this metal are to be diſſolved in half a gros of nitric acid. The ſolution muſt be poured into half a pint of diſtilled water, into which a cylinder of phoſphorus, two inches long, weighing forty-eight grains, muſt be plunged. The ſurface becomes almoſt immediately black, and is covered with particles of copper poſſeſſing the metallic colour and brilliancy. At the end of ſeveral days, octahedral cryſtals are ſeen, whoſe inſertions into each other produce elegant dendrites; and at the end of ten days the twelve grains of copper are completely reduced, as is proved by pouring ammoniac into the water. If it do not exhibit a blue colour, it is proof that the fluid contains no copper.

2. Copper mineralized by ſulphur forms the yellow ore of copper.

This ore is of a golden colour, and the ig-

norant are often deceived by its flattering appearance. It contains a larger quantity of copper in proportion as the ſulphur is leſs in quantity, and gives fewer ſparks with the ſteel. It ſometimes cryſtallizes in beautiful octahedrons. I poſſeſs two ſpecimens covered over with trihedral pyramids of near an inch long, and between four and five lines in diameter at the baſes.

When the ſulphur is ſo abundant that the proportion of copper will no longer pay for the working, the ore is called Marcaſite. The marcaſite cryſtallizes in cubes or in octahedrons, which eaſily effloreſce.

The yellow copper ore is found in various ſtates, according to the courſe of its decompoſition. The firſt impreſſion of hepatic vapours colours the ſurface in a thouſand ſhades, in which ſtate it is known by the name of Peacocks Tail, Pigeons Neck, &c.

The laſt degree of alteration of this ore, effected by the ſimple diſengagement of ſulphur, forms the hepatic copper ore. The yellow colour is then converted into an obſcure brown colour: this ore appears then to contain no other principles but water, copper, and iron, which laſt is always more or leſs abundant in theſe ores.

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The yellow copper ore ſometimes forms ſulphate of copper in its decompoſition. This ſalt is diſſolved in water, and forms ſprings more or leſs loaded with it, from which the copper may be obtained by cementation. Old iron is thrown into the water; the copper is precipitated, and the iron takes its place. In this way it is obtained in Hungary, and we might uſe this œconomical proceſs in ſeveral parts of our province. I have ſtalactites in my collection, ſent me from Cevennes, which are coloured blue by a very conſiderable quantity of copper. In Gevaudan, at half a quarter of a league from St. Leger de Peyre, ſeveral ſprings of water impregnated with copper are found, which run into a valley. The inhabitants of this canton drink a glaſs of the water occaſionally as a purgative.

The ſkeletons of animals are ſometimes found in copper-mines penetrated with that metal. Swedenburg has given an engraving of the figure of the ſkeleton of a quadruped taken out of a copper-mine, and coloured by that metal. In the royal cabinet there is a human hand, green at the extremity of the fingers, the muſcles of which are dried, and greeniſh. According to the report of Mr. Leyel, conſul of mines, there was found at Fahlun in Sweden, in the great cop-

per mine, a human carcaſe, which had remained there forty years, with the fleſh and bones entire, without corruption, and without emitting any ſmell. The body was clothed, and entirely incruſted with vitriol.—Acta Literaria Suec. tri. i. anno 1722, p. 250.

The turquoiſe ſtones are merely bones coloured by the oxides of copper. Mr. De Reaumur, in the year 1725, gave an account to the Academy of the turquoiſes found in Lower Languedoc. The colour of the turquoiſe frequently becomes converted into green, which depends on the alteration of the metallic oxide. The turquoiſe of Lower Languedoc emits a fetid ſmell by the action of fire, and is decompoſed by acids. The turquoiſe of Pruſſia emits no ſmell, and is not attacked by acids. Mr. Sage ſuſpected that the oſſeous part is agatized in theſe laſt.

3. Grey copper ore.—The copper is mineralized by arſenic. It has a grey colour, and an appearance nearly vitreous. It uſually contains ſilver; and, when wrought to extract this precious metal, it is called the Grey Silver Ore. It affects a tetrahedral form; and arſenic is the moſt predominant of its principles.

4. The grey antimonial copper ore.—This differs from the former, becauſe it contains ſulphur

phur and antimony, and is much more difficult to be wrought. When expoſed to the fire, it becomes as fluid as water; the ſulphur is volatilized with the antimony and the arſenic. The reſidue of the torrefaction is a mixture of the antimony and copper, and ſometimes it contains ſilver likewiſe.

5. Copper ores, in their decompoſition, are reduced to a more or leſs perfect ſtate of oxidation. The carbonic acid frequently unites to the metal, and becomes the mineralizer. This ſubſtance is known by name of Mountain Blue, Azure of Copper, Mountain Green, Malachite.

A. The azure of copper cryſtallizes in rhomboidal tetrahedral priſms, rather flattened, terminating in dihedral ſummits: theſe cryſtals are of the moſt beautiful blue; they are frequently altered by expoſure to the air, and become converted into malachite.

Mr. Sage has imitated the azure, both in the form and colour, by diſſolving copper, in the cold, in water ſaturated with carbonate of ammoniac. When the azure of copper is of a leſs brilliant colour, and in the pulverulent form, it is called Mountain Blue.

B. The malachite, cryſtallized in octahedrons, has been found in Siberia. This ore is frequently ſtriated, formed into ſmall tufts of

a ſilky appearance, or in very cloſe parallel fibres. The malachite is frequently covered with protuberances. This figure appears to announce that it has been formed in the ſame manner as the ſtalactites.

Mountain green differs from the malachite only in its pulverulent form, and the mixtures which alter it. The alterations of the copper ores, and native copper likewiſe, produce a cupreous oxide, which bears the name of Red Copper Ore. The mine of Predanah, in the county of Cornwall, has afforded the fineſt ſpecimens of red copper ore. The metal is nearly in the metallic ſtate, and has the form of octahedral cryſtals. The granular red copper ore differs from this only in its figure. It ſometimes has a brown martial earth for its gangue.

The azure, the malachite, and the red copper require no other proceſs but mere fuſion with coal to convert them into metal; the other kinds require to be cleared of their mineralizer by torrefaction, and afterwards to be fuſed with three parts of black flux.

To aſſay a ſulphureous copper ore, Mr. Exchaquet propoſes to take two gros of the crude ore, and one of the nitrate of pot-aſh; which, after pulverization, are to be detonated in an ignited crucible. The matter becomes hard after the

detonation;

detonation; upon which the fire is to be increafed and kept up, in order that the fulphur may be diffipated. The fire is then to be ftill more ftrongly urged, until the ore enters into fufion; and a mixture of half an ounce of tartar, one quarter of an ounce of falt, and a fmall quantity of charcoal, is to be added in equal portions. An effervefcence takes place at each projection of the mixture. The fire is then to be ftill more ftrongly raifed, and the crucible covered, and kept in this ftate for half an hour, in order that the copper may flow into a mafs. In this way a very malleable button of copper is obtained.

The working of copper ores varies according to their compofition. But, as the fulphureous ores are moft commonly wrought, we fhall confine ourfelves to the procefs which is moft fuitable to their nature.

The metal is firft picked or forted; afterwards pounded in a mill, and wafhed, to feparate the gangue, and other foreign fubftances; it is then roafted, to drive off its mineralizer; and afterwards fufed in the blaft furnace. The refult of this firft fufion is black copper; which is again fufed in the refining furnace, to diffipate all the fulphur which has withftood the preceding operations. When it is very pure, it is

poured into a broad veſſel, or teſt; a ſmall quantity of water is thrown on its ſurface, which, being by that means cooled, ſeparates from the reſt, and is taken up. This is the copper in roſettes, which is taken to the hammer to be beat into proper form. The ſeveral operations are different in various places. In ſome countries, the ore is roaſted as often as eight times; in others, one or two are ſufficient; and in ſome places it is not roaſted at all. This variety depends— 1. On the variations of practice: thoſe who roaſt but little, employ more time and care in the fuſion and refining. 2. On the nature of the ore: when it is rich in iron, the roaſtings are neceſſary to diſpoſe this metal to fuſion.

The method of roaſting is likewiſe prodigiouſly varied. Pieces of the mineral are ſometimes heaped up on a bed of combuſtible matter, and in this manner the calcination is performed; but, when this ore abounds with ſulphur, it may be extracted by the ingenious proceſs uſed at St. Bell, and deſcribed by Meſſrs. Jars in their excellent work.

The fuſion is commonly performed in the blaſt furnace; but at Briſtol, in England, the ore is roaſted in a reverberatory furnace, and fuſed into black copper.

The refining furnace conſtructed at St. Bell, by

by Meſſrs. Jars, appears to me to be one of the beſt. They have publiſhed an excellent deſcription of it, which may be conſulted in their Mineralogical Travels. The refining of copper conſiſts in depriving it of the ſulphur and iron which it may ſtill retain. The ſulphur is diſſipated by fire, and bellows properly directed; and the iron is ſcorified by the aſſiſtance of ſome pounds of lead fuſed with the copper. The ſkilful mineralogiſts whom I have juſt quoted, make uſe of a reverberatory furnace, lined with charcoal; and fuſe and ſkum their copper, without uſing lead.

When the copper contains a ſufficient quantity of ſilver to admit of extraction, the following proceſs is uſed:—1. Seventy-five pounds of copper are fuſed with two hundred and ſeventy-five of lead. The alloy is caſt into flat pieces, which are called Loaves of Liquation. 2. Theſe loaves are expoſed to a heat ſufficient to fuſe the lead, which carries the ſilver with it, and leaves the copper, which, on account of its being more difficult to fuſe, retains the original form of the loaves; and is every where penetrated by the interſtices through which the fuſed metal made its eſcape; theſe are called Dried Loaves of Liquation. 3. They are carried into a ſecond furnace, where they are expoſed

to

to a ſtronger heat, to deprive them of the ſmall quantity of lead which they ſtill retain. 4. The lead is afterwards taken to the cupel, where it is fuſed, and ſeparated from all the ſilver it had taken up.

Copper is altered by long expoſure to the air. Its ſurface becomes covered with a greeniſh coating, which is very hard, and known to the antiquarians under the name of Patin. This is the ſeal which atteſts the antiquity of ſtatues and models covered with it.

Copper, expoſed to the fire, becomes blue, yellow, and at laſt violet. It does not flow until it is ſtrongly ignited. When in contact with the coals, it gives a blue greeniſh tinge to the flame; and, if it be kept a long time in fuſion, part of it is volatilized.

When copper is heated in contact with air, it burns at its ſurface, and becomes changed into a blackiſh red oxide. This oxide may be ſeparated by ſtriking the plate which has been ignited, or by plunging it in water. When the oxide has been pounded, and more ſtrongly calcined, it aſſumes a brown red colour, and may be converted into a glaſs of a brown colour by a more violent heat.

1. The ſulphuric acid only acts on copper when concentrated, and very hot. It

then diſſolves it, and eaſily affords blue cryſtals of a rhomboidal form. The ſulphate of copper is known in commerce by the name of Blue Vitriol, Cyprian Vitriol, Blue Copper, &c.

Two methods are uſed to make the ſulphate of copper which is met with in commerce. The firſt conſiſts in calcining the cupreous pyrites, and cauſing them to effloreſce, in order to develope the ſalt, which is then extracted by lixiviation. The ſecond conſiſts in forming this pyrites artificially, burning it, and lixiviating it, to extract the ſalt.

This ſalt poſſeſſes a very ſtrong ſtyptic taſte. It is eaſily fuſible by heat, which diſſipates its water of cryſtallization, and changes its colour to a blueiſh white. The ſulphuric acid may be extracted by a very ſtrong fire. Lime and magneſia decompoſe this ſalt; and the precipitate is of a blueiſh white colour. If it be dried in the open air, it becomes green. Ammoniac likewiſe precipitates the copper in a whitiſh blue: but the precipitate is diſſolved nearly at the ſame inſtant that it is formed; and the reſult is a ſolution of a beautiful blue colour, known by the name of Aqua Celeſtis.

This ſalt contains in the quintal thirty pounds acid, forty-three water, and twenty-ſeven copper.

2. The

2. The nitric acid attacks copper with effervescence, at the same time that it becomes decomposed, and emits abundance of nitrous gas. When it is proposed to obtain this gas by the action of the acid upon the copper, it is necessary to have the precaution of weakening the acid, and to present the copper in pieces of considerable magnitude. If these circumstances be not attended to, the acid attacks the metal with such violence, as suddenly to emit a prodigious quantity of gas; immediately after which an absorption takes place, and the water of the jar passes into the bottle. In this case ammoniac is formed. The diluted nitric acid perfectly dissolves copper: the solution is blue. If it be speedily concentrated, no other result is obtained but a magma without crystals; but if it be left exposed to the air, it affords crystals in long parallelograms. By leaving a solution of this kind to spontaneous evaporation, I have obtained rhomboidal crystals, which, instead of being blue, as they are usually described, are white. They decrepitate upon the coals, emit a red gas by mere heat, and nothing remains but a grey oxide.

3. The muriatic acid does not dissolve copper unless it be boiling and concentrated; the solution is green, and affords prismatic crystals of considerable regularity when the evaporation

tion is flow. This muriate is of an agreeable grafs-green colour; its tafte is cauftic, and very aftringent: it fufes by a gentle heat, and congeals into a mafs; in which the acid is fo adherent, that a very ftrong fire is required to difengage it. It is very deliquefcent. Ammoniac does not diffolve the oxide of this muriate with the fame facility as it does that of the other cupreous falts. This obfervation was made by Mr. De Fourcroy; which I think may be explained from the circumftance that the muriatic acid fuffers the copper to be precipitated in the metallic form, inftead of giving out a portion of its oxigene, which would facilitate the action of the alkali.

4. The acetous acid, when made to act either hot or cold upon copper, only corrodes it, and produces the fubftance known in commerce by the name of Verdigris. The verdigris which is moft ufed in the arts has been long fabricated at Montpellier exclufively. The prejudice which prevailed, that the cellars of this city alone were proper for this operation, preferved this commerce till lately in its hands. But the progrefs of information has fucceffively put it in the power of other countries to partake in this manufacture.

The procefs ufed at Montpellier confifts in ferment-

fermenting the refuſe of grapes with ſour wine *. This refuſe is afterwards laid in alternate ſtrata, with plates of copper ſix inches long and five broad. In this ſtate they are left for a certain time; after which they are taken out, and placed edgewiſe in a cellar, where they are ſprinkled with ſour wine: in this ſituation the verdigris ſwells up; and is afterwards ſcraped off, put into ſacks of leather, and exported to foreign countries.

Ready-made vinegar is uſed at Grenoble, and the plates of copper are ſprinkled with it.

The verdet or verdigris of Grenoble contains one-ſixth leſs of copper: the vinegar which is obtained is ſtronger and more abundant. It has not the empyreumatic ſmell of that of Montpellier. The copper is therefore partly diſſolved in the verdet of Grenoble; becauſe it has been firſt reduced into an oxide by the impreſſion of the vinegar, and afterwards attacked by the ſubſequent affuſion of the ſame acid. It is therefore an acetate of copper.

The oxides of copper, diſſolved in vinegar, form a ſalt known by the name of Cryſtallized Verdigris, Cryſtals of Venus, Acetate of Copper.

* Vinaſſe.

To obtain this ſalt, the vinaſſe or ſour wine is diſtilled; and this weak vinegar boiled on the verdigris. The ſolution is then conveyed into a boiler, where it is concentrated until a pellicle appears. Sticks are then plunged in the bath; and at the end of a certain number of days the ſticks are again taken out, covered with rhomboidal cryſtals of a blue colour. Theſe cluſters of cryſtals, weighing each from four to ſix pounds, are wrapped up in paper, and diſtributed for ſale.

The vinegar may be diſengaged by diſtillation from theſe cryſtals; and the reſidue is a cupreous oxide, which poſſeſſes the characters of pyrophorus.

Vinegar, diſtilled on mangaueſe, diſſolves copper; which proves that it has taken up oxigene. The acetic acid, or radical vinegar, differs from ordinary vinegar, in containing a greater quantity of oxigene; and it is this oxigene which renders it proper to diſſolve copper in the metallic ſtate. The acetate of copper may likewiſe be formed by decompoſing ſalt of Saturn, or ſugar of lead, by the ſulphate of copper. The ſulphate of lead falls down; and the ſolution, when concentrated, affords the cupreous acetate.

5. The pure fixed alkalis, digeſted in the cold

cold with filings of copper, become of a blue colour; but ammoniac diſſolves it much more ſpeedily. I put copper filings into a bottle with very cauſtic ammoniac, and kept the bottle ſtopped for two years; the copper was deprived of its colour, and became ſimilar in appearance to a grey clay: whereas a ſimilar veſſel, in which I had placed the ſame mixture, but left open, ſoon afforded me very ſmall blue cryſtals; and the whole concluded by affording only a hard ſtratum of green matter, reſembling malachite.

Copper is precipitated from its ſolutions by iron. For this purpoſe nothing more is required than to leave the iron in one of the ſolutions of the other metal, which need not be ſtrong. The phenomenon may be rendered very ſurpriſing, by pouring the ſolution of the ſulphate of copper upon the clean ſurface of a piece of iron; for this ſurface inſtantly becomes covered with copper. The copper obtained by this means, is known by the name of Copper of Cementation.

This precipitation of one metal by another, has given riſe to a belief that the iron was converted into copper: and I could, from my own knowledge, mention the names of individuals who have been impoſed on by this phenomenon.

Copper mixes with moſt of the metals; and forms—

1. With arſenic, the white tombac.

2. With biſmuth, an alloy of a reddiſh white colour, with cubic facets.

3. With antimony, a violet-coloured alloy.

4. It may be combined with zinc by fuſion, or by cementation with lapis calaminaris. By the firſt proceſs, ſimilor, or the Manheim gold, is obtained; the produce of the ſecond is braſs.

5. Copper, plunged in a ſolution of mercury, aſſumes a white colour, which ariſes from the mercury which is diſplaced by the copper.

6. Copper is eaſily united with tin; and on this depends the art of tinning: for which purpoſe it is neceſſary to clean the ſurface of the metal perfectly; becauſe the oxides do not combine with the metals. This firſt object is accompliſhed by rubbing the metal intended to be tinned with the muriate of ammoniac, or by ſcraping it effectually; or even by paſſing a weak acid over its whole ſurface. After this operation the tin is applied by fuſing it in the veſſel intended to be tinned, then ſpreading it about with old rags rolled up; and the oxidation of theſe metals is prevented by means of pitch.

Copper, fuſed with tin, forms bronze, or bell-

 metal.

metal. This alloy is more brittle, whiter, and more ſonorous, in proportion to the quantity of tin which enters into its combination : it is then uſed to make bells. When it is intended to be applied to the purpoſe of caſting ſtatues, or forming great guns, a larger proportion of copper is uſed ; becauſe in this caſe ſolidity is one of the firſt requiſites.

7. Copper and iron contract very little union.

8. Copper, alloyed with ſilver, renders it more fuſible ; and theſe two metals are combined to form ſolders. Hence it is that verdigreaſe is occaſionally obſerved in pieces of ſilver, at thoſe parts where joinings have been made by means of ſolder.

Copper precipitates ſilver from its ſolution in the nitric acid. This method is uſed in the mints, to ſeparate the ſilver from the acid, after the operation of parting.

Copper is very much uſed in the arts. All the boilers in dye-houſes which are intended to contain compoſitions that do not attack this metal, are made of copper.

It is at preſent uſed as a ſheathing for the bottoms of ſhips. All our kitchen utenſils are made of it ; and, in ſpite of the danger to which we are daily expoſed of being poiſoned, and notwith-

notwithſtanding the flow and deſtructive impreſſion which this metal cannot but produce upon us individually, there are few houſes from which this metal is yet baniſhed. It is a deſirable object that a law might be paſſed to prohibit its uſe amongſt us ; as has been done in Sweden, at the ſolicitation of the Baron De Schoffer, to whom the public gratitude has erected a ſtatue of the ſame metal. It is an allowable infringement of perſonal liberty, when government take upon them to direct the conduct of individuals, in ſuch a manner as to ſecure their own ſafety. There is no year paſſes in which ſeveral perſons are not poiſoned by hams, or other food which is ſuffered to remain in copper veſſels.

Tinning is not a complete remedy againſt this danger ; for it leaves an infinity of points where the copper is uncovered *.

The ſulphate of copper is very much uſed in dying. The cryſtals of Venus, and verdigreaſe, are likewiſe uſed in painting ; they enter into the compoſition of colours, varniſhes, &c.

* It may beſides be doubted whether the extremely thin white coating, which conceals the internal ſurface of tinned copper, be not a kind of bell or ſpeculum metal, inſtead of tin, as it is generally ſuppoſed to be. T.

The various alloys of copper with the metals, render it highly valuable in the arts. Brafs, bronze, and bell-metal, are very extenfively ufeful.

CHAP. XII.

Concerning Mercury.

MERCURY differs from all other metals, by its property of retaining the fluid ftate, at the ordinary temperature of the atmofphere.

It poffeffes the metallic opacity and briliancy; and even acquires malleability, when deprived of fluidity by a proper degree of cold. The beft afcertained experiment which has been made on this phenomenon, was performed by the Academy of Peterfburgh, in 1759. The natural cold was increafed by a mixture of fnow and highly concentrated nitric acid; and the thermometer of De Lifle was caufed to fall to 213 degrees, which correfponds with 46 below

low o of Reaumur. At this period the mercury appeared to deſcend no lower: the bulb of the thermometer being then broken, the metal was found to be in a congealed ſtate, and bore to be flattened by the hammer. Mr. Pallas congealed mercury, in 1772, at Kraſnejark, by the natural cold: he then found that it reſembled ſoft tin. It has been aſcertained in England that the degree of its congelation was the 32d of Reaumur. Mr. Matthew Gutherie, conſul at the court of the Empreſs of Ruſſia, proved that the degree of cold of this congelation was 32 degrees below o of Reaumur; and that, when the mercury is purified by antimony, it congeals at 2 degrees lower.—See the Journal Encyclopédique, September 1785 *.

Mercury is as indeſtructible by fire as gold and ſilver; and its properties in general have cauſed it to be arranged among the perfect metals.

A cubic foot of this metal weighs 949 pounds; and its ſpecific gravity is 13,5681.—Briſſon.

Mercury has been found in the earth in five different ſtates.

1. Virgin Mercury is found in moſt of the

* For an account of this ſubject, ſee Dr. Blagden's Hiſtory of the Congelation of Mercury, in the ſeventy-third volume of the Philoſophical Tranſactions.

mines of this metal. Heat alone, or mechanical divifion of the ore, is fufficient to exhibit it in the metallic form.

Native mercury has been found in digging the foundations of fome houfes at Montpellier; and this metal has been conftantly mixed and confounded with a grey or red clay, which forms a bed almoft continuous, at a few feet beneath the foundation of this town.

The obfervations which I have had occafion to make on this fubject, have afcertained that the mercury exifts in a ftratum of decompofed grit-ftone, very argillaceous, ferruginous, and ochreous; of a red, brown, or grey colour. In this clay, the globules of mercury, in confiderable abundance, were eafily diftinguifhable, lying upon greyifh plates. Traces are perceived which refemble dendrites; and its impreffions are formed by layers of the oxide of mercury.

Several pounds of mercury have likewife been found in a well at Vienne in Dauphiny; and Mr. Thouvenel has pointed out to us three mines of this metal in the fingle province of Dauphiny, according to the indications of Bleton.

2. Mr. Sage read to the Academy, on the 11th of May 1782, the analyfis of an ore of mercury,

mercury, in the form of a ſolid oxide, which came from Idria in Friuli. It is of a brown red colour; and its fracture is granulated. It is reducible by mere heat; and affords oxigenated gas. It emits only half the quantity afforded by red precipitate; becauſe this oxide contains metallic mercury. It affords ninety-one pounds of mercury per quintal, and a ſmall quantity of ſilver.

3. The muriate of mercury, or corneous mercury, has been found native in the mine of Muſchel-Lamburg, in the duchy of Deux-Ponts. Mr. Sage obtained eighty-ſix pounds of mercury per quintal.

Mr. Woulfe has likewiſe diſcovered, in 1776, a very ponderous white, green, or yellow cryſtallized ore of mercury; in which he proved the exiſtence of the ſulphuric and muriatic acids.

4. Mercury is ſometimes naturally amalgamated with other metals, ſuch as gold, ſilver, arſenic, copper, &c.

5. Mercury is uſually mineralized by ſulphur; and the product is cinnabar or æthiops, according to the colour.

Cinnabar is found under different forms. 1. In red cryſtals, conſiſting of two triangular pyramids, truncated, and joined baſe to baſe,

or elſe ſeparated by a very ſhort intermediate priſm. Cinnabar has likewiſe been found cryſtallized in tranſparent plates.

2. Cinnabar is almoſt always found in maſſes, more or leſs compact; the colour varies from deep black to the brighteſt red. In this laſt ſtate it is diſtinguiſhed by the name of Vermilion.

Cinnabar has for its gangue, quartz, clay, calcareous earth, ponderous ſpar, and even coal. The ore which the Germans called Brandertz, has for its gangue a bituminous matter, which burns perfectly well; and it affords only ſix pounds of mercury in the quintal.

The principal cinnabar mines which are wrought in Europe, are thoſe of the Palatinate and thoſe of Spain. Mr. Sage informed us, in 1776, of the proceſs uſed in the Palatinate; and we are indebted to Mr. De Juſſieu for a deſcription of the method uſed in Spain.

In the Palatinate, the pounded and ſifted ore is mixed with one-third of lime; and the mixture introduced into iron cucurbits, one inch thick, three feet nine inches long, one foot wide, with an opening of five inches. Theſe veſſels are diſpoſed in a gallery. Forty-eight of theſe retorts being arranged in two parallel lines, a ſecond row is placed above the firſt. To the neck of each cucurbit an earthen pot is adapted,

which

which is one-third filled with water, and accurately luted on. The gallery is heated at the two extremities; ſeveral apertures formed in the dome ſerve the purpoſe of chimneys; and the diſtillation is effected by a fire kept up for ten or twelve hours.

This proceſs was followed at Almaden till the year 1647, when the following was adopted, as being more ſimple and œconomical. The furnace is twelve feet high, and four feet and a half diameter within. At the diſtance of five feet and a half from the ground, is an arch upon which the ore is diſpoſed, and a fire is kindled in the aſh-hole. The ſublimed mercury eſcapes through twelve apertures formed in the upper part of the laboratory. To theſe apertures, rows of aludels, inſerted one in the other, are adjuſted, and diſpoſed parallel upon a terrace, which terminates in a ſmall building ſeparated into as many chambers as there are files of aludels. Each chamber has a cavity in the middle, to receive the ſmall quantity of mercury which may arrive to that diſtance.

Every furnace contains two hundred quintals of cinnabar, and the fire is kept up for three days. The ſulphur which burns is diſengaged in the form of ſulphureous acid, and eſcapes through ſmall chimneys made in each chamber.

Every

Every repetition of the proceſs affords from twenty-five to ſixty quintals of mercury.

The mine of Almaden has been wrought from time immemorial. Its veins are from three to fourteen feet in breadth; and their breadth is even larger where they join.

Hitherto no method has been diſcovered to fix mercury but that of extreme cold. This metallic ſubſtance, naturally fluid, is capable of riſing even by a very moderate fire; as is proved by an experiment of Mr. Achard, who having left a diſh containing twenty pounds of mercury over a furnace which was daily heated, experienced a ſalivation at the end of ſeveral days; as did likewiſe two other perſons who had not quitted the chamber. He eſtimates this heat at about eighteen degrees of Reaumur.—Journal de Phyſique, October 1782.

It is dangerous to oppoſe the evaporation or dilatation of this metal which is produced by heat.

In the year 1732 an alchemiſt preſented himſelf to Mr. Geoffroy, pretending he had diſcovered the means of fixing mercury. He incloſed the metal in an iron box, and this box in five others, which were placed in a furnace; the exploſion was ſo ſtrong, that it burſt through the

the boards of the floor. Mr. Hellot has related a ſimilar fact to the Academy.

Mercury boils in the ſame manner as other liquids when it is heated; and for this purpoſe it does not even require a very conſiderable heat; the ebullition conſiſts merely in its tranſition to the vaporous ſtate: for it may be diſtilled like other fluids, and by that means cleared of its impurities. Boerhaave had the patience to diſtil the ſame mercury five hundred times ſucceſſively; and the metal ſuffered no other change, than that it afforded a grey powder, which required only trituration to convert it again into running mercury.

Mercury is not eaſily changed in the air; but if the action of the air be aſſiſted by heat, the mercury gradually loſes its fluidity; and at the end of ſeveral months forms a red oxide, which alchemiſts have diſtinguiſhed by the name of Precipitate per ſe. The apparatus made uſe of for this operation is a very large and very flat bottle, cloſed with a ſtopper, in which there is a capillary perforation. The mercury within the bottle by this means poſſeſſes the contact of air; and by diſpoſing the apparatus upon a ſand bath, and keeping up the ſtate of ebullition in the fluid, the oxide may be obtained in the courſe of ſeveral months.

This

This oxide gives out its oxigene by ſimple heat, without any intermedium; and the mercury reſumes its metallic form: one ounce affords about a pint. A quintal of mercury takes up about eight pounds of oxigene. The red oxide of mercury, expoſed to heat, ſublimes in cloſe veſſels, and may be converted into a very beautiful glaſs. I have obſerved this on all occaſions when I have made the red oxide by means of the nitric acid, according to the proceſs which I ſhall immediately deſcribe.

It is certain that mercury upon which water is boiled, communicates a vermifuge property to that liquid, though the moſt accurate experiments of Lemery have ſhewn that the metal does not perceptibly loſe weight; which proves that the principle taken up by the water is very fugaceous, and ſo light that it does not conſtitute any ſenſible part of the weight. Water which has remained for a certain time over mercury contracts a very evident metallic taſte.

1. The ſulphuric acid does not act upon mercury unleſs aſſiſted by heat. In this caſe, ſulphureous gas is diſengaged; and a white powder falls down, the quantity of which becomes greater in proportion as the acid is decompoſed. This oxide weighs one third more than the mercury made uſe of. It is cauſtic: if hot water be

poured on it, it becomes yellow; and if it be urged by a violent heat, it affords oxigenous gas, and the mercury resumes its natural form. This yellow oxide, obtained by means of the sulphuric acid, is known by the name of Turbith Mineral. It has long been considered as a sulphate of mercury. Mr. Baumé has proved that it does not contain a particle of acid; and it appears that the water which developes its yellow colour, seizes the small quantity of undecomposed acid which was mixed with the oxide. If the water which has been poured on it be evaporated, a salt is obtained in small, soft, and deliquescent needles, which may be deprived of their acid by the simple affusion of water. This fluid precipitates the mercury from them in the form of turbith.

2. The nitric acid of commerce, at the strength of thirty-five degrees, dissolves mercury with violence, even without the assistance of heat. This solution is accompanied with the disengagement of a considerable quantity of nitrous gas; because it is necessary that the acid should reduce the metal to the state of oxide before it can act upon it. One part of the acid is consequently employed in disposing the metal for solution, and the other dissolves it in proportion as it is oxided. This is what happens when

when the ſulphuric acid is digeſted upon a metal; one portion is decompoſed, and reduces the metal into an oxide, while the other diſſolves it.

The manner of effecting the ſolution of mercury in the nitric acid, has an influence on the properties of the mercurial nitrate. Bergmann has obſerved that the ſolution which is made ſlowly and quietly, without diſengagement of nitrous gas, affords no precipitate on the addition of water; whereas that which is made by the aſſiſtance of heat, and with loſs of nitrous gas, affords a precipitate. It appears that the nitric acid, aſſiſted by heat, is capable of becoming loaded with an exceſs of mercurial oxide, which it lets fall when diluted with water.

The method of performing the ſolution, and the proceſs made uſe of to cryſtallize it, has an equal influence upon the form of the cryſtals. 1. The ſolution made in the cold, and left to ſpontaneous evaporation, affords cryſtals which appeared to Mr. De Liſle to be octahedral pyramids, truncated near their baſe, and having the four angles reſulting from the junction of the baſes of their pyramids likewiſe truncated. 2. If the ſame ſolution be evaporated, long and acute blades are obtained, lying one upon the other, and ſtriated obliquely acroſs. 3. The ſolution of

of mercury effected by heat, affords flat and acute needles, ſtriated lengthways.

The nitrate of mercury is corroſive; it detonates upon coals when it is very dry, and emits a whitiſh flame of conſiderable brilliancy.

The mercurial nitrate, heated in a crucible, is fuſed, and emits a conſiderable quantity of nitrous gas, together with its water of cryſtallization. The remaining oxide becomes yellow; and at length aſſumes a lively red colour, and forms the ſubſtance called Red Precipitate. In order to make a very fine red precipitate, the mercurial ſolution muſt be put into a retort, and diſtilled until no more vapours come over. An additional quantity of nitric acid muſt then be poured on the remainder, and likewiſe diſtilled off. After three or four repeated diſtillations, a very beautiful precipitate is obtained in ſmall cryſtals, of a very ſuperb red colour.

The ſolution of mercurial nitrate forms mercurial water. It is of uſe to aſcertain the preſence of ſulphuric and muriatic ſalts in mineral waters.

The acids, the alkalis, the earths, and ſome of the metals, likewiſe precipitate mercury from its ſolution in the nitric acid. Theſe precipitates always conſiſt of the oxides of mercury in a greater or leſs degree of perfection, according

to

to which circumſtances their colour is ſubject to variation. On this head, Lemery, Baumé, &c. may be conſulted.

Mr. Bayen has diſcovered that ſome of theſe precipitates poſſeſs the property of fulminating, when mixed with a ſmall quantity of ſublimed ſulphur. This chemiſt has pointed out three— 1. The precipitate of mercury from its ſolution in the nitric acid by the aſſiſtance of the carbonate of ammoniac. 2. The precipitate of the ſame fluid by lime-water. 3. The precipitate of the ſolution of corroſive ſublimate by lime-water. Half a gros is to be triturated with ſix grains of ſublimed ſulphur. After the detonation, a violet-coloured powder remains, which affords a fine cinnabar by ſublimation.

3. The muriatic acid does not ſenſibly act upon mercury: but if it be digeſted for a long time upon the metal, it oxides it, and at length diſſolves the oxide, as may be concluded from the experiments of Homberg, inſerted in the volume of the Academy of Sciences for the year 1700.

The muriatic acid completely diſſolves the mercurial oxides. When theſe oxides are nearly in the metallic ſtate, or charged with a ſmall quantity of oxigene, the muriate of mercury is formed. When, on the contrary, the oxide

of

of mercury is saturated with oxigene, the oxigenated muriate of mercury, or corrosive sublimate of mercury, is formed.

Corrosive sublimate may be formed according to two methods; in the dry way, or in the humid way.

To make this salt in the dry way, the operator may proceed in various manners.

1. Equal parts of dried nitrate of mercury, decrepitated muriate of soda, and sulphate of iron calcined to whiteness, are mixed together. This mixture being exposed to sublimation, the product which arises is corrosive sublimate.

2. Running mercury is used in Holland instead of the nitrate of mercury; and the same results may be obtained by using any oxide of mercury whatever.

3. Equal parts of the sulphure of mercury, and the decrepitated muriate of soda, afford the same salt by sublimation. This process of Kunckel has been revived by Boulduc.

4. Mr. Monet assures us that he obtained corrosive sublimate by treating the dry muriate of soda, and a mercurial oxide, in the way of distillation in a retort.

If mercury be dissolved in the oxigenated muriatic acid, the solution, when concentrated, affords very fine corrosive sublimate.

It may likewise be obtained by precipitating the mercury from mercurial water by the same acid, and evaporating the solution.

I have obtained very fine sublimate by presenting a mercurial oxide, sufficiently loaded with oxigene, to the ordinary muriatic acid. One pound of muriatic acid, at the strength of twenty-five degrees, poured upon one pound of red oxide by the nitric acid, discolours it, in a short time dissolves it with a violent heat; and this solution, diluted with water, and properly evaporated, affords from twelve to fourteen ounces of crystals of corrosive sublimate.

The corrosive muriate of mercury has a styptic taste, followed by an exceedingly disagreeable metallic taste. When placed on hot coals, it is dissipated in fumes; when slowly heated in subliming vessels, it rises in prismatic crystals, so much flattened, that their faces are scarcely distinguishable. The assemblage of these has induced authors to compare them to sword blades lying across each other.

This salt is soluble in nineteen parts of water; and when the solution is concentrated, it affords crystals similar to those obtained by sublimation.

Barytes, magnesia, and lime decompose this salt. Half a gros of corrosive sublimate in powder,

powder, thrown into a pint of lime-water, forms a yellow precipitate. This fluid is known by the name of Phagedenic Water.

Fixed alkali precipitates the mercury in an orange-coloured oxide; and volatile alkali in the form of a white powder, which becomes brown in a ſhort time.

The ſame muriatic acid, combined with a leſs perfect oxide of mercury, forms the mild muriate of mercury, or mercurius dulcis. This combination may likewiſe be made by two methods; by the dry, or the humid way.

1. In the dry way, four parts of corroſive muriate of mercury are triturated in a mortar with three of running mercury. When the mercury has diſappeared, the mixture is put into phials, and ſublimed three ſucceſſive times, in order that the combination may be more accurate. This ſublimate differs from corroſive ſublimate by its inſolubility in water, its inſipidity, and the form of its cryſtals, which are tetrahedral pyramids, terminated by four-ſided pyramids. To obtain this regular form, it is neceſſary that the ſublimation ſhould be made at a moderate heat; for, if the heat be ſufficient to liquefy the ſalt, the reſult is merely a cruſt, with no appearance of cryſtals. As the trituration of corroſive ſublimate is dangerous, on ac-

count of the powder which riſes, Mr. Baumé pours a ſmall quantity of water upon the mixture. This liquid accelerates the trituration, and prevents the riſing of the deſtructive powder.

Mr. Bailleau has likewiſe propoſed the incorporating of corroſive ſublimate with water, and triturating it with running mercury. The combination is completed by digeſting the mixture on a ſand bath by a gentle heat. The matter becomes white, and requires only a ſingle ſublimation. Whenever it is ſuſpected that mercurius dulcis ſtill retains a portion of corroſive ſublimate, nothing more is neceſſary to be done than to triturate it, and pour boiling water upon it; for by this means the whole of the ſoluble ſalt which may have remained, is carried off.

Mr. Baumé has proved that there is no intermediate ſtate between mercurius dulcis and corroſive ſublimate. If leſs mercury be added to the ſublimate, a proportional quantity of mercurius dulcis only ſublimes, and the reſt riſes in the form of corroſive ſublimate; if a greater quantity of mercury be added than is neceſſary to convert the whole into mercurius dulcis, the exceſs remains in the form of running mercury.

The ſame chemiſt has likewiſe proved, that a

portion

portion of the mercury is always loſt at each ſublimation; and that a ſmall quantity of corroſive ſublimate is formed, which ariſes from the alteration of the mercury. Hence it follows that the mercurial panacea, which is made by ſubliming mercurius dulcis eight or nine times, is a more ſuſpicious remedy than the mercurius dulcis itſelf.

2. Mercurius dulcis may likewiſe be made by decompoſing mercurial water by a ſolution of the muriate of ſoda. The white precipitate which is obtained may be ſublimed, and forms an excellent mercurius dulcis. I communicated this proceſs to the Society of Sciences at Montpellier, two years before Mr. Scheele made it known.

The corroſive muriate of mercury differs therefore from the mild muriate by the ſtate of its acid.

The mercurial oxides are equally ſoluble in the other acids.

3. A ſolution of borax, mixed with mercurial water, forms a very abundant yellow precipitate, which is nothing elſe but the combination of the acid of borax and mercury. A ſmall quantity of this ſalt remains in ſolution, which may be obtained in brilliant cryſtals by evaporation.

4. The acetous acid likewiſe diſſolves the oxide of mercury, and affords white foliated cryſtals.

Mercury precipitated from a ſolution of the acetate of mercury, combines with the acidulous tartrite of pot-aſh, and forms the vegeto-mercurial water of Preſſavin.

The acetate of mercury is the baſis of Keyſer's pills.

5. Mercury, artificially mixed with ſulphur, forms the red or black ſulphures, known, on account of their colour, by the names of Æthiops or Cinnabar.

To form the æthiops, or black oxide of mercury, three methods may be followed.

1. Four ounces of mercury may be triturated with twelve ounces of ſublimed ſulphur in a glaſs mortar. The reſult is a black powder, called Æthiops Mineral.

2. Four ounces of ſulphur may be fuſed in a crucible, and one ounce of mercury extinguiſhed in it. The mixture readily takes fire, but the inflammation is to be prevented; and the blackiſh reſidue, being pounded, affords a greeniſh powder, which is a true æthiops.

3. The æthiops may be made by pouring the ſulphure of pot-aſh upon mercurial water.

Theſe æthiops afford by ſublimation cinnabar,

bar, or the red ſulphurated oxide. But in order to make it with a greater degree of accuracy, four ounces of ſublimed ſulphur are fuſed in an unglazed earthen pot, and one pound of mercury mixed with it by ſtirring or agitation. When theſe ſubſtances have combined to a certain degree, the mixture ſpontaneouſly takes fire, and is ſuffered to burn about a minute. The flame is then ſmothered, and the reſidue pulverized, which forms a violet powder, uſually weighing about ſeventeen ounces five gros. This powder, being ſublimed, affords a ſublimate of a livid red colour; which, when pounded, exhibits a fine red colour, known by the name of Vermilion.

Three parts of cinnabar, mixed with two ounces of iron filings, afford very pure mercury by diſtillation, which is called mercury revived from cinnabar. Lime, the alkalis, and moſt of the metals, may be ſubſtituted inſtead of the iron.

Mercury amalgamates with moſt other metals. On this property is founded the art of water-gilding, or gilding upon metals, the tinning of glaſſes, the working of gold and ſilver mines, &c.

Mercury is likewiſe uſed in the conſtruction of meteorological inſtruments, in which it poſſeſſes the advantage over other fluids—1. That

it does not eafily freeze. 2. It is more eafily and gradually dilatable, according to the fine experiments of Meffrs. Bouquet and Lavoifier. 3. It is very nearly of the fame quality in different fpecimens.

Mercury may be ufed in fubftance as a remedy againft the volvulus, and it has never been obferved to produce bad effects. It is mixed with fat, to form unguents very much ufed in venereal cafes. Thefe are prepared with one-third or half their weight of mercury, according to the exigence of the cafe.

The mercurial water is ufed as an efcharotic.

The red oxides anfwer the fame purpofe.

The mild mercurial muriate is ufed as a purgative. It enters into the compofition of pills which are ufed in venereal cafes, with the intention of carrying off the morbific matter by the fkin.

The corrofive muriate of mercury is of very extenfive ufe, more efpecially againft venereal diforders. This remedy requires fkill and prudence; but I have received it as the common opinion of all phyficians of reputation, that it is the moft powerful and certain remedy poffeffed by the art of medicine. In a large dofe it irritates the fyftem, affects the ftomach, occafions

occasions spasms in the lower belly, and leaves impressions which are difficult to be eradicated.

Cinnabar is used in fumigations, to destroy certain insects which attach themselves to the skin. It is likewise used as a pigment.

CHAP. XIII.

Concerning Silver.

SILVER is a metal of a white colour, possessing neither smell nor taste, nearly unalterable by fire, very ductile and tenacious. A cubic foot of this metal cast weighs seven hundred and twelve pounds; the specific gravity of cast silver is 10,1752. See Brisson.—It is found in the earth in five different states, which we shall proceed to consider.

1. Virgin or native silver.—Native silver is found in various forms. 1. In ramifications composed of octahedrons inserted one in the other. This variety is known by most mineralogists under the name of Virgin Silver in Vegetation. Four processes, indicated by Mr. Sage,

Sage, are known for the cryſtallization of ſilver: amalgamation, reduction by phoſphorus, reduction by copper, and fuſion.

A detail of theſe four proceſſes may be ſeen in his Analyſe Chimique, book iii. p. 238, et ſeq.

Native ſilver is likewiſe found in ſmall capillary, flexible, and intertwined threads. The decompoſition of the red or vitreous ſilver gives riſe to this ſpecies; it may even be produced by a ſlow calcination of one of theſe ores.

Silver is likewiſe found in irregular forms; either in ſmall plates diſperſed in the gangues, or in maſſes. Albinus reports, in the Chronicle of the Mines of Miſnia, that in the year 1478 a lump of native ſilver was found at Schneeburg, weighing four hundred quintals. Duke Albert of Saxony deſcended into the mine to ſee this ſurpriſing maſs of ſilver, and had dinner ſerved up upon it.

2. The vitreous ſilver ore, or ſilver mineralized by ſulphur.—This ore is of a grey colour, and may be cut like lead. It cryſtallizes in octahedrons, or in truncated cubes, and is moſt frequently found of an indeterminate figure. The ſulphur may be extracted by heat. It affords about ſixteen pounds in the quintal.

When the ſulphur is contained in a greater pro-

proportion in this ore, it becomes black, porous, and friable.

3. Red filver ore: filver mineralized by fulphur and arfenic.—This fpecies cryftallizes in hexahedral pyramids, terminating in an obtufe trihedral pyramid, with rhombic faces. It is frequently found in irregular maffes of no determinate figure. It poffeffes the colour and tranfparency of the ruby.

Mr. Sage has obtained from this ore, by diftillation, water, carbonic acid, and the fulphurated yellow and red oxides of arfenic. If this ore be calcined in a teft, and the mineralizer be fuffered to exhale, the refidue is found to be in the metallic ftate, exhibiting contorted threads of filver at its furface. Part of the filver paffes to the ftate of grey oxide in this operation.

4. White antimonial filver ore: filver and antimony mineralized by fulphur.—This ore is as white as filver; it is brittle, and of a granulated fracture. Sometimes it is found in hexahedral prifms, truncated, and flat at each end: this kind is found in the principality of Furftenburg. When expofed to heat, it becomes as fluid as water, emits antimony and fulphur, and leaves the filver behind, together with an oxide of antimony. This femi-metal is cleared off

off by fusion, assisted by proper fluxes, and cupellation.

5. The corneous ore of silver, or muriate of silver.—This species is of a dirty yellow grey: it is soft, and may be easily broken or cut. A gentle heat causes it to flow; it sublimes without decomposition, is most frequently found of no regular form, but sometimes crystallized in cubes. The muriatic acid is its mineralizer. Mr. Woulfe has shewn that it likewise contains a small quantity of sulphuric acid.

6. Silver is also very frequently alloyed with various metals, such as lead, copper, bismuth, cobalt; and these ores are sometimes wrought on account of the quantity of silver they contain.

The manner of working a silver ore varies according to its nature; but all the processes used in various countries may be reduced to the following:

1. In Peru and Mexico the mineral is pounded, roasted, washed, and afterwards triturated with mercury in copper boilers filled with water kept at the boiling heat. The whole is agitated by means of a kind of mill. The amalgam is afterwards expressed in a skin; then heated, to drive off the remaining mercury; after which process the silver remains alone.

This

This method is defective—1. Becaufe the fire volatilizes a portion of the muriate of filver which abounds in thefe ores. 2. The wafhings carry with them a portion of the oxide of filver. 3. The mercury does not amalgamate either with the muriates of filver, or the fulphates of that metal.

2. When filver ores, mineralized by fulphur or arfenic, are to be wrought, they are roafted, pounded, wafhed, and fufed with lead. This metal feizes all the filver, from which it is again feparated by cupellation.

3. When the filver ore is poor, it is fufed with cupreous pyrites, and the mixture treated in the way of liquation.—See the article Lead.

To determine the degree of purity of the filver, a given weight of filver is fuppofed to be compofed of twelve parts, called pennyweights; each pennyweight is divided into twenty-four grains. Silver, clear of all mixture, is faid to be twelve pennyweights fine.

In order to affay filver, and to afcertain its degree of finenefs, the regulation of the Court of Monies of France prefcribes, that thirty-fix grains of filver be taken, and wrapped in a plate of lead containing no fine metal, and then expofed to cupellation. From the lofs which the button of filver that remains on the cupel has

 fuffered,

ſuffered, a judgment is made of the quantity of alloy. If the loſs be one-twelfth of the whole, the ſilver is ſaid to be eleven pennyweights fine. The details relating to this operation may be ſeen in *L'Art d'eſſayer l'Or et l'Argent, par M. Sage.*

Silver may be rendered hard by mixing it with copper; and for this reaſon it is alloyed with that metal for ſilverſmiths work, as well as for the coinage. The law permits one-twelfth of alloy in ſilver money *; and it is this portion of copper which renders the ſolution of ſilver coin in the nitric acid blue.

Silver is not changed by the contact of air. A conſiderable heat is required to fuſe it; but it may be volatilized by a ſtrong fire without alteration, as is proved by the capital experiments of the Academicians of Paris, made in the focus of the lens of Mr. Trudaine. This metal emits a thick fume, which whitens plates of gold expoſed immediately over it.

Junker converted ſilver into glaſs, by treating it in a way of reverberation, after the manner of Iſaacus Hollandus, in a very ſtrong fire.

Macquer, by expoſing ſilver twenty times ſucceſſively to the porcelain furnace of Seves, obtained glaſs of an olive green colour. It was likewiſe obſerved that this metal, when expoſed

* The Britiſh coinage is 11 ounces 2 pennyweights fine. T.

to

to the focus of a burning mirror, preſented a white pulverulent matter on its ſurface, and a greeniſh vitreous covering on the ſupport upon which it was placed.

Though theſe experiments clearly prove that ſilver is capable of combining with oxigene, the difficulty which is found in effecting this combination, and the facility with which this air is diſengaged from the oxides of ſilver, prove that there is but little affinity between theſe two ſubſtances.

If ſilver in a ſtate of extreme diviſion be preſented to the concentrated and boiling ſulphuric acid, ſulphureous gas is diſengaged: the ſilver is reduced into a white matter, which is a true oxide of ſilver; and contains a ſmall quantity of ſulphate, which may be obtained in ſmall needles, or in plates formed by the union of theſe needles lengthways, as Mr. De Fourcroy has obſerved. This ſalt flows by heat, and is very fixed. If ſilver be precipitated by metals or alkalis, theſe precipitates are reducible without addition.

The nitric acid diſſolves ſilver with rapidity: much nitrous gas is diſengaged. The ſolution is at firſt blue: but this colour diſappears when the ſilver is pure; and degenerates into a green colour, if it be alloyed with copper. The nitric

acid

acid is capable of diſſolving more than half its weight of ſilver. The ſolution then lets fall cryſtals in hexagonal, triangular, or ſquare plates, which are called Nitrate of Silver, Lunar Cryſtals, Lunar Nitre, &c.

The ſolution of theſe cryſtals, generally known by the name of Solution of Silver, is very cauſtic. It colours the ſkin black, burns the epidermis, and ſo completely deſtroys its organization, that the ſpot diſappears only by the renewing of the ſkin.

The nitrate of ſilver melts on burning coals; but if it be expoſed to a gentle heat, in earthen or metallic veſſels, it liquefies, and may then be caſt in moulds. This fuſed nitrate of ſilver forms the lapis infernalis. Care muſt be taken to pour it out as ſoon as it is fuſed; becauſe otherwiſe the acid would be diſengaged, the ſilver would be revived, and the lapis infernalis, or lunar cauſtic, would loſe its virtue.

Lapis infernalis, made with pure ſilver, and prepared as above deſcribed, is whitiſh; whereas it is blackiſh when ſuffered to remain in fuſion for any time.

Lapis infernalis is very frequently mixed with nitrate of copper. This fraud is reprehenſible, becauſe it is an alloy which renders wounds of a bad character.

The

The lapis infernalis is uſed as an eſcharotic, and to corrode fungous excreſcences.

Silver may be precipitated from its ſolution by lime-water, alkalis, and ſeveral metals. Theſe laſt exhibit very important phenomena.

1. A plate of copper, immerſed in a ſolution of ſilver diluted in water, precipitates the metal. It adheres at the moment of precipitation to the ſurface of the copper, where it forms a kind of moſs. In proportion as the ſilver is precipitated, the water aſſumes a blue tinge; which proves that the copper is diſſolved in the nitric acid, in the room of the ſilver. When the whole of the ſilver is diſengaged, the water is to be decanted, the ſilver dried, and fuſed in crucibles, to be caſt into ingots. This ſilver almoſt always retains a ſmall quantity of copper; of which it may be deprived by cupellation with lead, which renders the ſilver pure: this proceſs is uſed in the mints, where the parting operation of gold from ſilver is performed. The firſt ſtep conſiſts in ſeparating the ſilver by means of nitric acid; and this is afterwards precipitated by the addition of copper.

2. The ſilver is likewiſe precipitated by mercury. In this operation it amalgamates with a ſmall quantity of the mercury, and forms tetrahedral cryſtals terminated by a tetrahedral py-

ramid, which cryſtals are articulated into each other. This arrangement gives them the form of a vegetation; and has cauſed the precipitate to be known by the name of the Tree of Diana, *Arbor Dianæ*. Lemery, Homberg, and other chemiſts, have ſucceſſively publiſhed proceſſes to produce this phenomenon; but that which has ſucceeded beſt in my hands, is deſcribed by Mr. Baumé. Six gros of the ſolution of ſilver, and four of that of mercury, both well ſaturated, are taken, and diluted with five ounces of diſtilled water. Theſe are to be put into a conical veſſel; and an amalgam of ſeven parts of mercury, and one of ſilver, is to be poured in. A multitude of ſmall cryſtals inſtantly appear to diſengage themſelves from the ſurface of the amalgam, upon which new ones articulate themſelves; and a vegetation is produced, which perceptibly riſes under the eye of the ſpectator. To render this phenomenon more ſtriking, I decant the exhauſted water, and ſubſtitute freſh: by this means I can fill any veſſel whatever with theſe vegetations. The mercury amalgamated with the ſilver, in this operation, may be ſeparated by means of fire.

The muriatic acid does not diſſolve ſilver, but it ſpeedily diſſolves its oxides. The oxigenated muriatic acid diſſolves ſilver.

To produce a certain and ſpeedy combination of the muriatic acid with ſilver, this acid is to be poured into a ſolution of the nitrate of ſilver. A precipitate immediately falls down, which is known by the name of Luna Cornea. This muriate of ſilver is very fuſible; and runs into a grey and tranſparent ſubſtance, conſiderably reſembling horn. If a ſtronger degree of heat be applied, it is decompoſed, part is volatilized, and the other part reduced into ſilver.

The muriate of ſilver, expoſed to the light of the ſun, becomes brown in a ſhort time. Oxigenous gas is diſengaged; which may be collected by placing it under water, according to the proceſs of Mr. Berthollet. Moſt of the ſolutions of the metals have the ſame property. Lunar nitre likewiſe becomes coloured, and emits its oxigene and nitrous gas.

One pound of boiling water does not diſſolve more than three or four grains of muriate of ſilver, according to the obſervation of Mr. Monet. The alkalis are capable of decompoſing the muriate of ſilver, and ſeparating the metal. The ſilver may be diſengaged from its muriate by fuſion with three parts of black flux.

Mr. Berthollet has taught us the following

 proceſs,

procefs, to form the moft dreadful and the moft aftonifhing fulminating powder we have yet been acquainted with. Take fine filver of cupellation; diffolve it in the nitric acid; precipitate this folution by lime-water; decant the water, and expofe the oxide for three days to the air. Mr. Berthollet is of opinion that the prefence of light has fome influence in the fuccefs of this experiment.

Mix this dried oxide in ammoniac, or volatile alkali, and it will affume the form of a black powder: decant the fluid, and leave the powder to dry in the open air. This is the fulminating filver.

Gunpowder, and even fulminating gold itfelf, cannot be compared with this new product. The contact of fire is neceffary to caufe gunpowder to detonate; and a determinate degree of heat is required to caufe fulminating gold to fulminate: but the contact of a cold body is fufficient to produce the detonation of fulminating filver. In a word, this product, once obtained, can no longer be touched: no attempts muft be made to inclofe it in a bottle, but it muft be left in the capfule wherein the evaporation was performed.

It is ufelefs to obferve, that the fulmination ought not to be attempted but with fmall quantities;

tities; the weight of a grain, for example: for a larger mafs would give rife to a dangerous detonation. The neceffity of making this preparation with the face covered with a mafk with glafs-eyes, may be eafily conceived. It is prudent to dry the fulminating filver in fmall metallic capfules.

The following experiment will complete the notion which ought to be formed of the fulminating property of this preparation.

Take the ammoniac which was ufed in the converfion of the oxide of filver into the black precipitate which forms fulminating filver; put this ammoniac into a fmall mattrafs of thin glafs, and let it be fubjected to the degree of ebullition neceffary to complete the combination. Take the mattrafs from the fire; and a rough covering of cryftals will be formed on its internal furface which is beneath the fluid. If one of thefe cryftals beneath the cold fluid be touched, an explofion takes place which breaks the mattrafs.

The procefs for obtaining fulminating filver being defcribed, its effects known, and the cautions neceffary for repeating the experiment being well afcertained, we fhall fpeak a word concerning the theory of the phenomenon: it is the

the ſame as that of fulminating gold, laid down by Berthollet.—See the Memoirs of the Royal Academy of Sciences for the year 1785.

In this operation, the oxigene, which adheres very ſlightly to the ſilver, combines with the hydrogene of the ammoniac. From the combination of the oxigene and the hydrogene, water in the ſtate of vapour is produced. This water, inſtantly vaporized, and poſſeſſing all the elaſticity and expanſive force of that ſtate, is the principal cauſe of the phenomenon; in which the nitrogene, which is diſengaged from the ammoniac, with its whole expanſibility, likewiſe bears a principal part.

After the fulmination, the ſilver is found reduced or revivified; that is to ſay, it has reſumed its metallic ſtate. It again becomes the ſame white, brilliant, and pure metal which it was when taken out of the cupel.

The principal uſe of ſilver is in coinage, as the repreſentative ſign of the value of other commodities.

Its metallic brilliancy has cauſed it to be adopted as an ornament; its hardneſs, and unchangeableneſs in the air, render it very valuable.

It is alloyed with copper, to form ſolder; whence

whence it happens that ſilver utenſils are ſubject to ruſt and verdigris, at the places where they are ſoldered.

CHAP. XIV.

Concerning Gold.

GOLD is the moſt perfect, the moſt ductile, the moſt tenacious, and the moſt unchangeable, of all the known metals. A cubic foot of pure gold, caſt and not hammered, weighs 1348 pounds; and its ſpecific gravity is 19,2581.—See Briſſon.

Gold has neither ſmell nor taſte; its colour is yellow, and this varies according to the purity of the metal.

1. As gold is ſubject to very little alteration, it is almoſt always found in the native ſtate; and under this form it exhibits the following varieties:—1. It is found in octahedrons in the gold mines of Boitza in Tranſylvania. Theſe octahedrons are ſometimes truncated in ſuch a

manner as to have the appearance of hexagonal plates. This native gold is alloyed with a ſmall quantity of ſilver; which, according to Mr. Sage, gives it a pale yellow colour. It has likewiſe been found cryſtallized in tetrahedral priſms, terminated by four-ſided pyramids. The amalgam made with certain precautions is likewiſe capable of cauſing gold to aſſume a form nearly ſimilar, according to Mr. Sage; and gold reduced by phoſphorus ſometimes exhibits octahedral cryſtals.

Gold likewiſe cryſtallizes by fuſion. Meſſrs. Tillet and Mongez obtained it in ſhort quadrangular pyramids.

2. Native gold ſometimes exhibits fibres or filaments of various lengths; it is likewiſe found in plates diſſeminated on a gangue. The gold ore of Lagardet, a few leagues diſtant from Allemont in Dauphiny, is of this kind. 3. Gold is likewiſe found ſometimes in ſmall plates or ſpangles, diſperſed in ſand or earths: under this form it is found in the auriferous rivers, ſuch as the Ariege, the Ceze, the Gardon, the Rhone. Theſe ſmall plates are ſometimes one line in diameter, but moſt commonly too ſmall to be ſeen by the naked eye. 4. Gold is ſometimes found in irregular maſſes; in which inſtance it is known by the name of Gold Duſt. Very large

large pieces of this kind are found in Mexico and Peru.

2. Gold is ſometimes mineralized by ſulphur, by the means of fire. The auriferous pyrites are frequently found in Peru, Siberia, Sweden, Hungary, &c. To aſcertain whether a pyrites contains gold or not, it muſt be pounded, and nitric acid poured upon it until it takes nothing more up. This ſolution muſt then be diluted with much water. The lighteſt inſoluble parts may be carried off by waſhings; and the reſidue, upon examination, will ſhew whether it contains gold or not.

When the martial pyrites is decompoſed, the gold is always diſengaged; and it is probable that the ſmall plates of gold in the auriferous rivers, are afforded by a decompoſition of this kind.

Gold is ſometimes mineralized by ſulphur, with the aſſiſtance of zinc, as in the gold mine of Nagyag. This ore likewiſe contains lead, antimony, copper, ſilver, and gold.

3. Mr. Sage has given a deſcription and analyſis of an arſenical ore of gold.

4. Gold likewiſe exiſts naturally in vegetables. Becher obtained it. Henckel affirmed that they contain it; and Mr. Sage has reſumed this enquiry, and found it according to the

the following table, which expreſſes the quantities of gold obtained from the quintal of the ſeveral earths.

	Ounce.	Gros.	Grains.
Rotted manure (terreau) -	0	1	56
Earth of uncultivated ground (terre de Bruyere)	0	2	36
Garden mould - -	0	5	0
Mould of a kitchen garden manured with dung yearly for ſixty years -	2	3	40

Theſe reſults were at firſt conteſted; but at preſent it appears to be generally agreed that gold is obtained, but in a leſs quantity. Mr. Berthollet obtained forty grains and eight twenty-fifths of gold in the quintal of aſhes. Meſſrs. Rouelle, Darcet, and Deyeux likewiſe obtained it.

It is therefore a phyſical fact, that gold exiſts in vegetables.

The method of working the ores of gold is nearly the ſame as that uſed with ſilver ores. When the gold is in a native ſtate, nothing more is required than to divide the ore by the pounding mill, and afterwards to waſh and amalgamate it. If the ore be mineralized, it is torrefied, pounded, waſhed, fuſed with lead, and afterwards cupelled. Eliquation is likewiſe uſed for poor ores.

Thoſe

Thoſe perſons who explore the gold in ſmall plates diſſeminated in the ſand of certain rivers, are known in France by the name of Orpailleurs, or Pailloteurs. The pailloteurs of the river Uze, after having aſcertained that the earth is ſufficiently rich to be wrought, place a table of ſeveral feet in length, and about a foot and a half in width, on the banks of the river, with ledges round three of its ſides. Pieces of ſtuff with a long nap are nailed on to this board; and the ſand is thrown upon it, and waſhed, to carry away the lighter particles. When the ſtuff is ſufficiently charged with the ſmall particles of gold, it is ſhaken into a veſſel, agitated with water, to carry off the lighteſt ſand, and afterwards amalgamated with mercury *. Mr. Ell has given us an ample account of the proceſs uſed in working the gold ores in Spaniſh

* For a very full account of the treatment of auriferous ſands, the following works may be conſulted:—1. The Memoir of Mr. Reaumur on the Auriferous Sands of France, printed among thoſe of the Academy for the year 1718. The Memoir of Mr. Guetard on the Ariege, inſerted in the volume for 1761. 3. The Memoir upon the Gold which is obtained from the Ariege in the county of Foix, by the Baron de Dietrich. In this laſt work, the various proceſſes are diſcuſſed; and this celebrated mineralogiſt propoſes others more œconomical and advantageous.

South

South America. A ſufficient quantity of water is procured to waſh them. A ſtream is made to carry off the earth, and every lighter ſubſtance. Negro ſlaves, diſperſed on the banks, throw in freſh earth; while others, ſtanding in the brook, work it about with their feet and hands. Care is taken to lay pieces of wood acroſs the current of the water, to retain the lighter particles of the metal. This work is continued for a month, and even for years together. When it is propoſed to terminate it, the water is turned off; and then, in preſence of the maſter, the workmen take up the ſand with wooden veſſels, in the form of ſhallow funnels, of one foot in diameter, at the bottom of which is an aperture of one inch in width. This diſh is filled with ſand; and by a circular motion the lighter ſubſtances are cauſed to flow off, while the heavier ſettle to the bottom. The platina is afterwards ſeparated grain by grain, with the blade of a knife, upon a ſmooth board. The reſt is amalgamated, firſt by working with the hands, and afterwards with a wooden peſtle in mortars of guaiacum wood; after which the mercury is ſeparated from the gold by fire.

The Baron de Born has reduced the method of working all the ores of ſilver and gold to one ſingle proceſs. The account which he has given of this

this proceſs in his work, may be reduced to the following operations:

1. The mineral is pounded, divided, and ſifted.

2. It is properly roaſted.

3. It is mixed with muriate of ſoda, water, and mercury; and agitation is uſed to facilitate the amalgamation.

4. The mercury is expreſſed from the amalgam.

5. The expreſſed mercury is expoſed to diſtillation.

6. The ſilver is refined by the cupel.

Theſe operations were firſt executed at Schemnitz in Hungary, and afterwards at Joackimſtal in Bohemia, in the preſence of the greateſt mineralogiſts in Europe, ſent thither by the various ſovereigns of Europe.

The muriate of ſoda is uſed to decompoſe the ſulphates produced by the calcinations.

To determine the fineneſs of gold with accuracy, the pureſt is ſuppoſed to be twenty-four carats, and theſe carats are divided into thirty-ſecond parts; the carat is always repreſented by a grain poids de marc.

The law directs the operations to be performed upon twenty-four grains of gold, tolerates twelve, and prohibits ſix, on account of

of the difficulty of appreciating the divisions which result from these small quantities.

In the parting assay, very pure silver must be made use of. This is mixed with the gold in the proportion of four to one, which has occasioned the name of Quartation to be given to the process. Mr. Sage has found that two parts and a half of silver to one of gold form the mixture most proper for making the cornet of assay. The two metals are wrapped up in a thin piece of lead four times the weight of the gold, and this mixture is put into the cupel when it is very hot. The result of the cupellation is a button containing fine gold and fine silver. This is flattened, lamellated, and rolled up into a spiral; put into a small mattrass, and six gros or drams of pure nitric acid, at thirty-two degrees of concentration, are poured on it. As soon as the mattrass is heated, the metal becomes brown, the silver is dissolved, and much red vapours are disengaged. At the end of fifteen minutes the solution is decanted; and an ounce of very pure acid, rather more concentrated, is poured on, to carry away the last portions of silver This solution is decanted, after a digestion of fifteen or twenty minutes; at which period warm water is added, and the cornet is washed until the water comes off tasteless. It is then

then dried in a crucible, weighed, and the fineneſs judged by the diminution of its weight.

Schindlers and Schutler have maintained that gold always retains a ſmall quantity of ſilver, which they have called the Interhalt, or Surplus. Mr. Sage found a ſixty-fourth part of a grain in the beſt conducted aſſay.

In order to ſeparate the ſilver which is diſſolved in the nitric acid, this ſolution is diluted with a conſiderable quantity of water, and flat pieces of copper are plunged in it; which precipitate the ſilver, as we have obſerved in treating of the ſolution of ſilver.

Gold, expoſed to fire, becomes red-hot before it melts. When melted it ſuffers no alteration *. Kunckel and Boyle kept it in a glaſshouſe furnace for ſeveral months without change.

Homberg has nevertheleſs obſerved that this metal, expoſed to the focus of the lens of Tſchirnaus, ſmoked, was volatilized, and even vitrified in part. Mr. Macquer has verified this obſervation by the mirror of Mr. De Trudaine; he obſerved the gold fume, become volatilized, and covered with a dull pellicle, which con-

* Gold, when fuſed by a ſtrong heat, is of a beautiful green colour during the fuſion. T.

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ſtituted a violet-coloured oxide towards the middle.

Gold is not attacked by the ſulphuric acid.

The nitric acid appears to have a real action upon it. Brandt is the firſt who announced the ſolution of gold by this acid. The experiments were made in the preſence of the King of Sweden, and verified by his Academy. Meſſrs. Scheffer and Bergmann have confirmed the aſſertion of Brandt; and Mr. Sage afterwards publiſhed a ſeries of experiments on this ſubject. I am convinced, from my own experiments, ſeveral times repeated, that the pureſt nitric acid attacked gold in the cold, and diſſolved a ſixty-fourth part of a grain. When very pure nitric acid is boiled upon gold equally pure, the ſolution may be aſcertained in three ways—1. By the diminution of the weight of the metal. 2. By evaporation of the acid; in which caſe a purple ſpot remains at the bottom of the evaporatory veſſel. 3. By the parting operation, by means of a plate of ſilver put into the liquor. In this caſe black flocks are in a ſhort time diſengaged, which conſiſt of the gold itſelf. Theſe phenomena appear to announce a true ſolution; and not a ſimple diviſion or ſuſpenſion, as was ſuppoſed.

The quantity of gold diſſolved appeared to

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me to vary according to the ſtrength of the acid, the time of the ebullition, and the thickneſs of the metallic body.

The nitro-muriatic acid, and the oxigenated muriatic acid, are the true ſolvents of gold. Theſe acids attack it with greater energy in proportion as they are more concentrated, and as the ſurface of the gold is larger. The ſolution may likewiſe be accelerated by heat.

This ſolution has a yellow colour, is cauſtic, and tinges the ſkin of a purple colour. If it be properly concentrated, it affords yellow cryſtals, reſembling topazes, which affect the form of truncated octahedrons. Theſe cryſtals are a true muriate of gold, according to Meſſrs. Bergmann, Sage, &c. If the ſolution of gold be diſtilled, a red liquor is obtained, which conſiſts of the muriatic acid, coloured by a ſmall quantity of gold which it has carried over. This fluid was diſtinguiſhed by the adepts under the name of Red Lion.

Gold may be precipitated from its ſolution of ſeveral colours, according to the nature of the ſubſtances employed to make the precipitation. Gold is precipitated by lime and magneſia in a yellow powder, in which the gold exiſts nearly in the metallic ſtate; a ſlight de-

gree of heat only being neceſſary to convert it to that ſtate.

The alkalis likewiſe precipitate gold in the form of a yellowiſh powder; and the precipitate is ſoluble in the ſulphuric, nitric, and muriatic acids. Theſe concentrated ſolutions ſuffer the gold to precipitate; cryſtals have not been obtained from them.

If ammoniac be poured on a yellowiſh ſolution of gold, the colour diſappears; but, at the end of a certain time, ſmall flocks are diſengaged, which become more and more yellow, and gradually ſubſide to the bottom of the veſſel. This precipitate, being dried in the ſhade, is known by the name of Fulminating Gold; a denomination which it has obtained on account of its property of detonating, when gently heated.

Ammoniac is abſolutely neceſſary to produce this effect.

The experiments of ſeveral chemiſts have taught us—1. That, by gently heating fulminating gold in copper tubes, one extremity of which was plunged in the pneumato-chemical apparatus by the aſſiſtance of a ſyphon, alkaline gas is obtained, and the precipitate is deprived of its fulminating property: this fine experiment

ment was made by Mr. Berthollet. 2. Bergmann has obſerved that, by expoſing fulminating gold to a gentle heat, incapable of cauſing it to fulminate, it becomes deprived of that property. 3. When the gold is made to fulminate in tubes whoſe extremities are inſerted under a veſſel filled with mercury, the product is nitrogene gas, and ſome drops of water. 4. By triturating fulminating gold with oily ſubſtances, it is deprived of its property of fulminating.

From theſe eſtabliſhed facts, it is evident that fulminating gold is a mixture of ammoniac and oxide of gold. When this mixture is heated, the oxigene is diſengaged at the ſame time with the hydrogene of the alkali. Theſe two gaſes take fire by ſimple heat, detonate, and produce water; the nitrogene gas then remaining alone. From theſe principles it ought to follow, that oily ſubſtances which combine with the oxigene, acids which ſeize the alkali, or a gentle and long-continued heat, which volatilizes the two principles without inflaming them, ought to deprive this preparation of its property of fulminating.

The nitrous ſulphur which Mr. Baumé ſuppoſed to be formed, in his explanation of this phenomenon, does not exiſt; for the ſolution of the oxide of gold by the ſulphuric acid, when

precipitated by ammoniac, affords a fulminating precipitate.

Gold is precipitated from its ſolution by ſeveral metals, ſuch as lead, iron, ſilver, copper, biſmuth, mercury, zinc, and tin. This laſt precipitates it inſtantly in the form of a powder, diſtinguiſhed by the name of the Purple Powder of Caſſius. This precipitate is much uſed in porcelain manufactories. Some very good obſervations on this preparation may be ſeen in the Dictionary of Macquer.

Gold may likewiſe be precipitated from its ſolution by ether: this liquor ſeizes the gold in a moment, and ſometimes inſtantly revivifies it. I have ſeen the gold form a ſtratum at the ſurface of the liquor, and the two fluids no longer contained a particle.

The ſulphures of alkali diſſolve gold completely. Nothing more is neceſſary for this purpoſe, than quickly to fuſe a mixture of equal parts of ſulphur and pot-aſh with one-eighth of the total weight of the gold in leaves. This ſubſtance may then be poured out, pulverized, and diſſolved in hot water. The ſolution has a yellowiſh green colour. Stahl affirms that Moſes diſſolved the golden calf by a ſimilar proceſs; and that, though the beverage muſt have been

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of a disagreeable taste, this circumstance was an additional reason for preferring the method, in order that the Israelites might longer retain their disgust for idolatry.

Gold unites with most of the metals.

Arsenic renders it brittle, as well as bismuth, nickel, and antimony. All these semi-metals render it white and eager.

Gold unites very well with tin and lead. These two metals deprive it of all its ductility.

Iron forms a very hard alloy with gold, which may be employed to much greater advantage than pure gold.

Copper renders it more fusible, and communicates a reddish colour to it. This alloy forms money, gold plate, and toys.

Silver renders it very pale. This alloy forms the green gold of goldsmiths.

Gold is employed in a variety of purposes. It is entitled, by the first rank which it holds among metals, to the most noble uses.

As its colour is agreeable to the eye, and is not subject to tarnish, it is used in ornaments, or as toys; for which purpose it is wrought into a thousand forms.

For some purposes it is drawn into very fine wire, and used in embroidery. For other purposes it is extended into leaves so extremely

 thin,

thin, that the ſlighteſt breath of wind carries them away: in this form it is applied upon wooden articles by means of ſize.

For other purpoſes it is reduced into a very fine powder; in which caſe it is called Ground Gold, Shell Gold, Gold in Rags, &c.

The ground gold is prepared by levigating the clippings of gold leaf with honey, waſhing them with water, and drying the particles which ſubſide.

Shell gold conſiſts of ground gold mixed with a mucilaginous water.

In order to make the gold in rags, pieces of linen are ſteeped in a ſolution of gold, afterwards dried, and then burned. When it is required to uſe them, a wet cork is dipped in wood aſhes, and rubbed upon ſuch articles of ſilver as are intended to be gilded.

For ſome purpoſes it is amalgamated with mercury. This amalgam is applied upon copper, the ſurface being previouſly well cleared. It muſt be ſpread very even, and the mercury driven off by heat. This forms the *or moulu*.

A coating of gilders wax is laid over the gold thus applied. This is made with red bole, verdigris, alum, and ſulphate of iron, incorporated and fuſed with yellow wax. The piece is heated a ſecond time, to burn off the wax.

Gold

Gold was formerly ufed in medicine. This remedy was much in fafhion in the fifteenth century. Its goodnefs has at all times been proportioned to the dearnefs of the drug. Bernard de Paliffy exclaimed ftrongly againft the apothecaries of his time, who demanded ducat gold from the fick to put into their medicines, under the pretence that the purer the gold the more fpeedy would be the reftoration of the health of the patient.

As this metal is highly valued, the rage of forming it conftituted a known fect, under the name of Alchemifts, which may be divided into two claffes. The one, very ignorant, frequently unprincipled, and moft commonly uniting both qualities, fuffered themfelves to be impofed on by certain phenomena, fuch as the increafe of weight of metals by calcination, the precipitation of one metal by another, and the yellow colour which fome bodies, and certain preparations, affect. They grounded their notions on certain vague principles concerning the formation of bodies, their common origin, their feeds, &c.

It is this fect which has caufed alchemy to be defined, *ars fine arte, cujus principium eft mentiri, medium laborare, tertium mendicare.* Thefe alchemifts, after having been themfelves the dupes

for a considerable time, always endeavoured to impose on others; and there are a thousand tricks and impositions related of this class of men, which deserves only to be despised and pitied.

There is another class of alchemists which does not deserve to be made the object of public derision and contempt. This is formed of celebrated men, who, grounding their ideas on the received principles, have directed their researches towards this object. This class of men is valuable on account of their genius, probity, and conduct. They have formed a language, held scarcely any communication but with each other, and have at all times distinguished themselves by their austere manners, and their submission to Providence. The celebrated Becher is a name which alone suffices to render this sect respectable. The following passage, extracted from Becher, exhibits an idea of their language, and manner of proceeding in this study.

" Fac ergo ex lunâ et sole mercurios, quos cum primo ente sulphuris præcipita, præcipitatum philosophorum igne attenua, exalta, et cum sale boracis philosophorum liquefac et fige donec sine fumo fluat. Quæ, licet breviter dicta sint, longo tamen labore acquiruntur et itinere, ex arenoso namque terrestri Arabico mari, in

in mare rubrum aqueum, et ex hoc in bituminoſum ardens mare mortuum itinerandum eſt, non ſine ſcopulorum et voraginum periculo, nos, Deo ſint laudes, jam appulimus ad portum." Becher, Phyſ. Sub. i. ſ. v. cap. iii. page 461. in 8vo. *And elſewhere*, "Concludo enim, pro theſi firmiſſima, aſinus eſt qui contra alchymiam loquitur, ſed ſtultus et nebulo qui illam practicè venalem exponit."

The enlightened alchemiſts have enriched chemiſtry with moſt of the products which were known before the late revolution. Their knowledge and their indefatigable ardour put them in the ſituation of profiting by all the intereſting facts which offered themſelves.

God forbid that I ſhould induce any perſon to enter into this path. I would uſe every effort to prevent any one from engaging in this reſearch, ſo full of diſappointment, and ſo dangerous to attach the mind to it. But I am of opinion that the alchemiſts have been too lightly treated; and that this ſect, which on many accounts is worthy of commendation, has not received the eſteem and gratitude it is entitled to.

In addition to theſe reaſons, I muſt obſerve that chemical phenomena become ſo wonderful; the torch of analyſis has enlightened us to ſuch an extent; we now decompoſe and reproduce

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ſo many ſubſtances, which ten years ago were conſidered with equal probability as indecompoſable as gold is now thought to be; that no chemiſt can take upon him to affirm that we may not arrive at the art of imitating nature in the formation of metals.

C H A P. XV.

Concerning Platina.

WE were unacquainted with platina until the year 1748. It is to Don Antonio Ulloa, who accompanied the French Academicians in their famous voyage to Peru, to determine the figure of the earth, that we are indebted for our firſt notions of this metal.

Charles Wood, who had himſelf brought this metal from Jamaica, made experiments upon it, which are related in the Philoſophical Tranſactions for the year 1749 and 1750.

Since that time, all the chemiſts in Europe procured this metal. Meſſrs. Scheffer in Sweden, Lewis in England, Margraaf in Pruſſia, Macquer,

quer, Baumé, De Buffon, De Milly, De Lifle, De Morveau, have fucceffively made refearches on this fubftance: and we are indebted for great part of our prefent knowledge of this metal to the Baron de Sickengen.

Platina has hitherto been found only in the metallic ftate. Its form is that of fmall grains, or flattened plates, of a livid white colour, intermediate between that of filver and iron: it is from this colour that it derived its name of Platina, or Little Silver. If the grains of platina be carefully examined, it is found that fome of them are rounded, and others angular.

It has been found among the auriferous fands of South America, near the mountains of the diftricts of Novita and Cytara. Thefe two metals are almoft conftantly accompanied by a ferruginous fand obedient to the magnet. The platina of commerce ufually contains a fmall quantity of mercury, arifing from the amalgamation which the ore has undergone in extracting the gold. When it is required to have platina in a very pure ftate, it muft be expofed to heat, to drive off the mercury; and the magnetical parts, and the iron, muft be forted out with the magnet. Platina itfelf is flightly attracted by the magnet. M. L. affirms, in a Memoir read to the Academy of Sciences at Paris in the year 1785, that

that the lighter pieces of platina only are attracted by the magnet, and that they ceafe to be acted on when they exceed a certain fize. The largeft piece of platina which has been feen, is of the fize of a pigeon's egg. It muft be in the poffeffion of the Royal Society at Bifca.

M. L. affirms that platina is malleable in its natural ftate; and he paffed it through the flatting mill in the prefence of Meffrs. Tillet and Darcet.

Platina undergoes no alteration by expofure to the air; and fire alone does not even appear to poffefs the power of changing it. Meffrs. Macquer and Baumé kept it feveral days in a glafs-houfe furnace, without its grains having fuffered any other change than that they were flightly agglutinated. It has neverthelefs been afcertained that heat, kept up for a long time, tarnifhes its furface, and increafes its weight. Margraaf formerly made this obfervation.

Platina, expofed to the focus of the burning mirror of Mr. De Trudaine, fumes and melts. This metal may be hammered like gold and filver. It may likewife be fufed upon charcoal, by the affiftance of oxigenous gas. This fubftance refifts the action of the acids, fuch as the fulphuric, the nitric, and the muriatic acids; it is foluble only in the oxigenated muriatic and the

the nitro-muriatic acids. One pound of the latter, digeſted on an ounce of platina, firſt aſſumes a yellow colour, then an orange colour, and laſtly a very obſcure brown. This ſolution tinges animal ſubſtances brown; it ſpontaneouſly depoſits ſmall irregular fawn-coloured cryſtals; but, if it be concentrated, larger cryſtals are obtained, ſometimes of an octahedral form, as Bergmann has obſerved. The muriate of platina is ſcarcely cauſtic, though ſharp; it fuſes in the fire, gives out its acid, and leaves an obſcure grey oxide.

The ſulphuric acid, poured on this ſolution, forms a precipitate of a dark colour; the precipitate occaſioned by the muriatic acid, is yellowiſh.

The alkalis precipitate platina from its ſolution; but, if it be gradually precipitated by potaſh, the precipitate is diſſolved by the alkali in proportion as it is formed.

A ſolution of the muriate of ammoniac, poured into a ſolution of platina, forms an orange-coloured precipitate, which is a true ſaline ſubſtance, totally ſoluble in water. This precipitate has been fuſed by Mr. De Liſle in a common fire (of a furnace). The reſult of the fuſion is platina, ſtill altered by ſome portion of

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faline matter ; for it does not acquire ductility but by expofure to a much ftronger heat.

The property which the muriate of ammoniac poffeffes, of precipitating platina, affords a very fimple method of afcertaining the mixture of this metal with gold : fo that the fear of this alloy, which had alarmed the Spanifh miniftry fo much as to occafion them to forbid its being wrought, does not at prefent exift, as we poffefs a fimple method of afcertaining the fraud : and it is much to be wifhed that this very precious metal fhould be reftored to the arts, to which it cannot but be very ufeful, by its brilliancy, its hardnefs, and its unchangeable nature.

The procefs of Mr. de Lifle to fufe platina, was publifhed in 1774. Mr. Achard publifhed a fimpler method, nearly at the fame time : it confifts in taking two gros of platina, two gros of the white oxide of arfenic, two gros of the acidulous tartrite of pot-afh, and putting them into a crucible well luted. This is to be expofed for an hour to a violent fire, which fufes the platina ; but it is brittle, and whiter than ordinary platina. It is then to be expofed to a confiderable heat under a muffle ; by which means all the arfenic which was combined with the platina is diffipated, and this metal left in a ftate of

of purity. Veſſels of platina may be formed, by filling clay moulds with the alloy of platina and arſenic; and expoſing the mould in the muffle, to diſſipate the ſemi-metal.

Mr. de Morveau ſubſtituted the arſeniate of pot-aſh to advantage, inſtead of arſenic; and he had already fuſed platina with his vitreous flux, made of pounded glaſs, borax, and charcoal.

Mr. Pelletier fuſed platina, by mixing it with phoſphoric glaſs and charcoal. The phoſphorus then unites with the platina; and the phoſphure of platina is expoſed to a degree of heat ſufficient to volatilize the phoſphorus.

Mr. Baumé adviſes to fuſe platina with a ſlight addition of lead, biſmuth, antimony, or arſenic; and to keep the alloy in the fire a long time, to diſſipate the metals which have facilitated the fuſion.

Platina may likewiſe be fuſed with a metal ſoluble in an acid: the mixture being pulverized, the alloyed metal may be diſſolved; and the powder of platina may then be fuſed with the flux of De Morveau.

Inſtead of uſing a ſoluble metal, a calcinable metal may be employed, and treated as before.

The cubic foot of crude platina weighs 1092 livres 1 ounce 7 gros 17 grains; platina purified

rified and fused weighs 1365 livres; and purified platina forged weighs 1423, 8, 7, 64.

Most of the neutral salts have no perceptible action on platina. The results of several curious experiments may be seen in the Memoirs of Margraaff.

The nitrate of pot-ash alters platina, according to the experiments of Lewis and Margraaff. Dr. Lewis, by heating a mixture of one part of platina and two parts of this nitrate, during three times twenty-four hours, observed that the metal assumed a rusty colour. By diffusing the mixture in water, the alkali was dissolved; and the platina, deprived of all the soluble matter, is diminished one-third. The powder taken up by the alkali is the oxide of iron, mixed with the oxide of platina.

These experiments, as likewise the property which platina possesses of being acted on by the magnet, prove that it contains iron; and Mr. de Buffon has concluded that this metal is a natural alloy of gold and iron. But it has been objected that the artificial alloy of these two metals, made in every possible proportion, never resembles platina; that this metal departs more from the properties of gold in proportion as it is deprived of iron: so that it is considered as a truly peculiar metal.

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This metal is capable of being alloyed with moſt of the known metals.

Scheffer firſt affirmed that arſenic rendered it fuſible.

Meſſrs. Achard and De Morveau have availed themſelves of this property to fuſe it, and compoſe veſſels.

Platina eaſily unites with biſmuth. The reſult is eager, brittle, difficultly cupelled; and the reſult is a maſs which has little ductility.

Antimony likewiſe facilitates the fuſion of platina. The alloy is brittle; part of the antimony may be diſengaged by fire; but a ſufficient quantity remains in combination to deprive the platina of its weight and ductility.

Zinc renders this metal more fuſible. The alloy is very hard; great part of the zinc may be volatilized by fire; but the platina always retains a ſmall quantity.

This metal unites eaſily with tin. This alloy is very fuſible, and flows clear; it is eager, and very brittle: but when the tin is in a large proportion, the alloy is ductile; its grain is coarſe, and it becomes yellow by expoſure to the air.

Lead unites very well with platina. A ſtronger heat is required to fuſe this than the foregoing alloy. It is not ductile; is no longer capable of being abſorbed by the cupel, the abſorp-

abſorption only taking place when the lead is in exceſs; but the platina remains always united to a conſiderable portion of the metal. Nevertheleſs Meſſrs. Macquer and Baumé cupelled one ounce of platina and twenty ounces of lead, by expoſing this alloy, for fifty hours, in the hotteſt part of the porcelain furnace at Seves. Mr. De Morveau had the ſame reſult in Mr. Macquer's wind-furnace: the operation laſted between eleven and twelve hours. Mr. Baumé obſerved that the platina obtained by this proceſs poſſeſſes the power of being forged and ſoldered completely, without the aſſiſtance of any other metal, which renders it a moſt valuable acquiſition in the arts.

Dr. Lewis could not unite forged iron with platina; but having melted crude iron with this metal, there reſulted an alloy ſo hard that the file could not touch it: it was ductile in the cold, but broke ſhort when hot.

Copper and platina alloyed together form a very hard metal, which is ductile, while the copper predominates in the proportion of three or four to one: it takes a fine poliſh, and was not tarniſhed during the ſpace of ten years.

Platina, alloyed with ſilver, deprives it of its ductility, increaſes its hardneſs, and tarniſhes its colour. Theſe two metals may be ſeparated

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by fusion and repose. Lewis observed that the silver which is fused with platina, is thrown up against the sides of the crucible with a kind of explosion: this phenomenon appears to be owing to the silver, as Mr. Darcet found it break porcelain balls in which it was inclosed, and out of which it was projected by the action of the fire.

Gold is not capable of being alloyed with platina but by the most violent heat: the colour of the gold is prodigiously altered, and the alloy possesses considerable ductility.

We know enough of the properties of this metal to presume that it will prove of the greatest use in the arts. Its almost absolute infusibility, and its unchangeableness, render it of extreme value to form chemical vessels, such as crucibles, and the like. The property of soldering or welding without mixture, renders it preferable to gold or silver.

Its density and opacity render it likewise of great value for the construction of optical instruments; and the abbé Rochon has constructed a mirror whose effect greatly surpasses that of the mirrors before made of steel and other metals. This metal unites two qualities never before found in one and the same sub-

 stance.

ſtance. Like other metallic mirrors, it reflects but one ſingle image; at the ſame time that it is as unchangeable as the mirrors of glaſs.

CHAP. XVI.

Concerning Tungſten and Wolfram.

WE are acquainted with two minerals which may be diſtinguiſhed by the generic title of Tungſten: the one white, and known by the name of Tungſten, or the Heavy Stone of the Swedes; the other known by the name of Wolfram by mineralogiſts. We ſhall examine each ſeparately.

ARTICLE I.

Concerning Tungſten.

Tungſten is a ſubſtance of an opake white colour, very heavy, and of a moderate degree of hardneſs:

hardneſs: its cryſtals are octahedrons. Its ſpecific gravity is 6,0665, according to Briſſon; from 4,99 to 5,8, according to Kirwan. The cubic foot weighs 424 livres 10 ounces 3 gros 60 grains.

When expoſed without addition to the flame of the blow-pipe, it decrepitates without melting. With ſoda it is divided with a ſlight effervescence; is partly ſoluble in the native phoſphate, or microcoſmic ſalt; and affords a fine blue colour, without the leaſt appearance of red in the refracted light, as happens with cobalt. It is ſoluble in borax without effervescence.

Bergmann affirms that by pouring the muriatic acid upon pulverized tungſten, the powder immediately aſſumes a fine bright yellow colour. To this character Scheele adds that of becoming blueiſh when boiled in the ſulphuric acid.

This ſubſtance has a ſparry appearance, and was long confounded with the white tin ore. It is found at Bitſberg, at Riddharhittan, at Marienberg, at Altemberg in Saxony, and at Saubergnear Ehrenfriederſdorff.

Mr. Raſpe, in Crell's Annals for June 1785, gave an account of two mines of tungſten in the province of Cornwall, from which thouſands of tons might be extracted. This philoſopher obtained

tained the metal in the proportion of about thirty-six livres the quintal. He adds that this metal contains little iron; that it is very fixed, and refractory in the fire; and that it acts on glass like the hardest steel.

Cronstedt arranges the tungsten among iron ores; and defines it to be *ferrum calciforme terrâ quâdam incognitâ intimè mixtum.*

Scheele has affirmed that it is a salt resulting from the combination of calcareous earth with a peculiar acid; which acid, combined with lime-water, regenerates tungsten.

Bergmann considers the acid earth of tungsten as a metallic acid.

Several processes are at present known for extracting the acid of tungsten.

1. Any desired quantity of this mineral is to be pulverized, and fused with four times its weight of carbonate of pot-ash, and poured out upon a plate of metal. The mass is then to be dissolved in twelve parts of boiling water. A white powder separates during the solution, and falls to the bottom of the vessel. This precipitate is a true carbonate of lime, mixed with a small quantity of quartz, and a portion of undecomposed tungsten. The carbonate of lime may be taken up from the precipitate by nitric acid; and the remaining tungsten being mixed

with the former proportion of carbonate of pot-ash, is to be fused, dissolved, and by a repetition of these operations will at length be totally decomposed. The water in which the fused masses were washed, holds in solution a salt formed by the tungstic acid and the alkali made use of. If this solution be saturated with nitric acid, it seizes the alkali; the solution becomes thick; and a white powder falls down, which is the tungstic acid.

2. Scheele, the author of this first process, proposes a second, which consists in digesting three parts of weak nitric acid upon one of pulverized tungsten. This powder becomes yellow; the fluid is then decanted, and two parts of ammoniac are poured upon the yellow powder. The powder then becomes white; and in this way the repeated actions of the acid and the alkali are applied until the tungsten is dissolved. Out of four scruples, treated by Scheele in this manner, there were three grains of insoluble matter, which was a true quartz. By adding the prussiate of pot-ash to the nitric acid made use of, he obtained two grains of Prussian blue; pot-ash precipitated three of chalk; and the ammoniac uniting to the nitric acid, precipitated an acid powder, which is the true tungstic acid.

In this experiment the nitric acid seizes the

 lime,

lime, and uncovers the tungſtic acid, which is ſeized by the alkali.

The muriatic acid may be ſubſtituted to advantage inſtead of the nitric acid, and even gives it a yellower colour.

Scheele and Bergmann conſidered this acid powder as the true tungſtic acid in a ſtate of purity. Meſſrs. Delhuyars have aſſerted that this acid was mixed with the acid made uſe of in obtaining it, and alſo with the alkali; they aſſert that the yellow powder which is uncovered by the digeſtion of the nitric acid, is the true acid oxide of tungſten without mixture.

The white powder which is obtained by decompoſing the alkaline ſolution of tungſten by an acid, is acid to the taſte, reddens the tincture of turnſole, precipitates the ſulphure of alkali of a green colour, and is ſoluble in twenty parts of boiling water.

Properties of the white powder obtained by decompoſing the ſolution of the ore of tungſten by an acid.	*Properties of the yellow matter obtained by fire or by acids.*
1. An acid taſte, reddening the tincture of turnſole.	1. Inſipid, reddening the tincture of turnſole.
2. Expoſed to flame urged by the blow-pipe, it paſſes to a brown	2. Treated with the blow-pipe, it preſerves its yellow colour

a brown and black colour, without affording either fumes or ſigns of fuſion.	colour in the external flame; but ſwells up, and becomes black, without fuſing, in the interior blue flame.
3. It is ſoluble in twenty parts of boiling water.	3. It is inſoluble, but capable of becoming ſo divided as to paſs through the filters.
4. It becomes yellow by boiling in the nitric and muriatic acids, and blueiſh in the ſulphuric acid.	4. The three mineral acids have no action upon it.

From this compariſon it appears that the acid is purer in the yellow powder than in the white; and the ſaline combinations of theſe two ſubſtances have confirmed Meſſrs. Delhuyar in their opinion.

The yellow acid, combined with pot-aſh, either in the dry or humid way, forms a ſalt with exceſs of alkali. If a few drops of nitric acid be poured on this ſalt, a white precipitate is inſtantly formed, which is rediſſolved by agitation. When all the alkali is ſaturated, the ſolution is bitter; if more acid be poured in, the precipitate which falls down is no longer ſoluble. This precipitate, when well edulcorated, is exactly of the ſame nature as the white powder we have ſpoken of. The experiments of Meſſrs. Delhuyar, and of Mr. De Morveau, prove very clearly that this white powder contains the

the acid of tungſten, a portion of the pot-aſh with which it was before combined, and a ſmall quantity of the precipitating acid.

It is therefore well proved that the yellow matter is the pure oxide, and the true tungſtic acid. It is likewiſe very certain that this acid exiſts ready formed in the metal; and that its oxigene is afforded neither by the decompóſition of another acid, nor the fixation of the oxigenous gas of the atmoſphere; it appears to exiſt in the mineral, and to conſtitute a kind of ſalt of many principles.

The pure tungſtic acid diſſolves ammoniac; but the reſult is always with exceſs of alkali. This ſolution affords by evaporation ſmall cryſtals, of a penetrating bitter taſte, ſoluble in water, and then reddening blue paper. The alkali is eaſily ſeparated; and theſe cryſtals return by calcination to the ſtate of yellow powder, entirely ſimilar to that which entered into its compoſition. If the calcination be made in cloſed veſſels, the reſidue is of a deep blue colour; for the yellow colour does not appear unleſs the calcination be made in the open air.

The experiments of Mr. De Morveau permitted him to claſs the affinities of this acid in the following order, which is the ſame as that

2 of

of the arſenical acid, lime, barytes, magneſia, pot-aſh, ſoda, ammoniac, alumine, metallic ſubſtances.

ARTICLE II.

Concerning Wolfram.

Wolfram is of a blackiſh brown colour, ſometimes affecting the form of an hexahedral compreſſed priſm, terminated in a dihedral ſummit. Theſe ſurfaces are frequently ſtriated longitudinally. Its fracture is lamellated, foliated, and the leaves are flat, though rather confuſed. Externally it reſembles ſchorl; but is not fuſible, and is incomparably heavier.

Some mineralogiſts have taken it for an arſenical ore of tin; others for mangaveſe, mixed with tin and iron. Meſſrs. Delhuyars, who made a ſtrict analyſis of it, found it to contain manganeſe 22, oxide $13\frac{1}{2}$, quartzoſe powder 2, yellow powder or tungſtic acid 65.

The wolfram which was analyſed by theſe chemiſts, came from the tin mines of Zinnwalde, on the frontiers of Saxony and Bohemia. Its ſpecific gravity was 6,835.

Wolfram does not melt by the blow-pipe without

without addition, its angles being ſcarcely rounded. With the native phoſphate, or microcoſmic ſalt, it melts with effervefcence, and affords a glaſs of an hyacinth colour.

It effervefces with borax, and forms a greeniſh yellow glaſs in the blue flame. This glaſs becomes red in the external flame.

Pulverized wolfram upon which the muriatic acid is boiled, aſſumes a yellow colour like tungſten.

Meſſrs. Delhuyars fuſed in a crucible two gros of pulverized wolfram, and four gros of pot-aſh. The fuſed mixture being poured out on a plate of copper, a black matter remained in the crucible; which, when well edulcorated, weighed thirty-ſeven grains, and was found to be a mixture of iron and manganeſe.

The maſs which had been poured out was diſſolved in water, filtered, and ſaturated with nitric acid. It afforded a white precipitate, abſolutely ſimilar to that obtained from tungſten by a ſimilar proceſs.

The proceſs of Scheele, by the humid way, ſucceeds equally well, and even appeared to Meſſrs. Delhuyars to be more advantageous. They prefer the diſengagement, by mere heat, of the ammoniac which holds the tungſtic acid in ſolution. One hundred grains of wolfram,

treated

treated with the muriatic acid and ammoniac, afforded them ſixty-five grains of a yellow powder, which is the pure acid.

This yellow acid powder unites with moſt of the metals. Meſſrs. Delhuyars relate the following facts:

1. One hundred grains of gold leaf, and fifty grains of the yellow matter, urged by a violent heat for three quarters of an hour, in a crucible lined with charcoal, afforded a yellow button, which crumbled in pieces between the fingers, and internally exhibited grains of gold, with others of a grey colour. This button weighed one hundred and thirty-nine grains; and was cupelled with lead, though with difficulty.

2. Similar proportions of platina and the yellow matter, treated in the ſame way (for an hour and a quarter), afforded a friable button, in which grains of platina were diſtinguiſhable, of a whiter colour than ordinary. It weighed one hundred and forty grains.

3. With ſilver, the yellow matter formed a button of a white greyiſh colour, rather ſpungy, which extended itſelf eaſily by a few ſtrokes of the hammer; but, on continuing them, it ſplit in pieces. This button weighed one hundred and forty-two grains, and the mixture was perfect.

4. With copper, it afforded a button of a coppery

coppery red colour, inclining to grey, which was ſpungy, and conſiderably ductile. It weighed one hundred and thirty-three grains.

5. With crude or caſt iron, of a white quality, it afforded a perfect button, whoſe fracture was compact, and of a greyiſh white colour. It was hard, brittle, and weighed one hundred and thirty-ſeven grains.

6. With lead, it afforded a button of an obſcure grey colour, with very little brilliancy, ſpungy, very ductile, and ſplitting into leaves when hammered. It weighed one hundred and twenty-ſeven grains.

7. The button formed with tin was of a lighter grey than the preceding, very ſpungy, ſomewhat ductile, and weighed one hundred and thirty-eight grains.

8. The button of antimony was of a bright grey, rather ſpungy, brittle, and eaſily broken; it weighed one hundred and eight grains.

9. That of biſmuth preſented a fracture which, when ſeen in one direction, was of a grey colour, and metallic luſtre; but in another direction it appeared like an earth without any luſtre: but in both caſes an infinity of pores were ſeen over the whole maſs. It weighed ſixty-eight grains.

10. The button formed with zinc was of a black

a black greyiſh colour, and an earthy aſpect, very ſpungy, and brittle: it weighed forty-two grains.

11. With common manganeſe it afforded a button of a blueiſh grey colour, and earthy aſpect. Its internal part, examined with a lens, reſembled an impure ſcoria of iron; it weighed one hundred and ſeven grains*.

Theſe experiments confirm the ſuſpicion of the celebrated Bergmann; who, from the ſpecific gravity of this ſubſtance, and its property of colouring the native phoſphate and borate of ſoda, concluded that it was of a metallic nature.

The change of colour which accompanies its reduction, its increaſe of weight by calcination, its metallic aſpect, and its uniting with other metals, are inconteſtable proofs of its metallic nature. The yellow matter muſt therefore be conſidered as a metallic oxide; and the button obtained by expoſing this oxide to a ſtrong fire, with powder of charcoal, is a true metal.

* In Cullen's Tranſlation of the Chemical Analyſis of Wolfram, printed in London in 1785, I find the word *brown* in every place where M. Chaptal has uſed the word *griſe*, or *grey*. Not having the original, I cannot ſpeak with certainty; but from circumſtances conclude this laſt to be right. T.

Meſſrs.

Meſſrs. Delhuyars having put one hundred grains of the yellow matter into a lined crucible well cloſed, and expoſed it to a ſtrong heat for an hour and a half, found upon breaking the crucible, when cold, a button which was reduced to powder between the fingers: its colour was grey. On examining it with the magnifier, an aſſemblage of metallic globules were ſeen, among which ſome were of the bigneſs of a pin's head, and when broken exhibited a metallic fracture reſembling ſteel. It weighed ſixty grains, and of courſe there was a diminution of forty. Its ſpecific gravity was 17,6. Having calcined a part of it, it became yellow with $\frac{24}{100}$ increaſe of weight. The nitric and the nitro-muriatic acid changed it into a yellow powder. The ſulphuric and muriatic acids diminiſhed its weight, and their ſolution let fall Pruſſian blue. The metallic grains always remained after the action of theſe acids. This metal ſhews various properties, which diſtinguiſh it from all others known. 1. Its ſpecific gravity is 17,6. 2. It forms peculiar glaſs with the ſeveral fluxes. 3. It is almoſt abſolutely infuſible, much leſs fuſible than mangaueſe. 4. Its oxide is of a yellow colour. 5. It forms peculiar alloys with the known metals. 6. It is inſoluble in the ſulphuric, muriatic, nitric, and nitro-muriatic

acids;

acids; and these two last convert it into an oxide. 7. The oxide combines with alkalis. 8. The oxide is insoluble in the sulphuric, nitric and muriatic acids, and assumes a blue colour with this last.

Wolfram ought to be considered as an ore, in which this metal is combined with iron and manganese, as Messrs. Delhuyar have proved.

CHAP. XVII.

Concerning Molybdena.

TWO substances have long been confounded together under the name of Black Lead Ore, Mineral Lead, Plumbago, and Molybdena, which the more accurate analysis of the celebrated Scheele has proved to be of very different nature.

Molybdena cannot be confounded with the mineral of which black lead pencils are made, which is called Plumbago. The characteristic differences are sufficiently evident to leave no doubt on this subject.

Molybdena is composed of scaly particles, either large or small, and slightly adherent to each other. It is soft and fat to the touch, soils the fingers, and makes a trace of an ash-grey colour. Its aspect is blueish, nearly re-

ſembling that of lead. The mark it makes on paper has an argentine brilliancy; whereas thoſe of plumbago are of a darker and leſs ſhining colour: its powder is blueiſh; by calcination it emits a ſmell of ſulphur, and leaves a whitiſh earth. The nitric and the arſenical acids are the only acids which attack it effectually; it is ſoluble in ſoda with effervefcence before the blow-pipe; it cauſes the nitrate of potaſh to detonate, and leaves a reddiſh reſidue; when expoſed to the flame of the blow-pipe in the ſpoon, it emits a white fume.

Plumbago is leſs fat, leſs granulated, and compoſed of ſmall brilliant particles. It loſes in the fire $\frac{98}{100}$ of its weight, and the reſidue is an oxide of iron.

Molybdena has been found in Iceland, in Sweden, in Saxony, in Spain, in France, &c. that of Iceland is found in plates, in a red feld ſpar mixed with quartz.

Mr. Haſſenfratz gave Mr. Pelletier ſamples of molybdena ſimilar to thoſe of Iceland, which he had collected in the mine named Grande Montagne de Chateau Lambert, near Tillot, where a copper mine was formerly wrought.

William Bowles appears to have found molybdena near the village of Real de Monaſterio: it is in banks of grit-ſtone, ſometimes mixed with granite.

The

The molybdena of Nordberg in Sweden is accompanied with iron that obeys the magnet.

The molybdena of Altemberg in Saxony nearly reſembles that of Nordberg.

Mr. Pelletier analyſed all theſe ſpecies; and his work may be conſulted in the Journal de Phyſique for 1785; but the experiments we ſhall here relate were made with that of Altemberg.

Molybdena, expoſed to heat on a teſt, becomes covered, after the ſpace of an hour, with a white oxide; which, when collected by a proceſs ſimilar to that uſed with the ſublimed oxide of antimony, has all the appearances of this laſt ſubſtance. The whole of the molybdena may by this means be converted into oxide. We are indebted to Mr. Pelletier for this fine experiment, which had eſcaped Scheele.

Molybdena is indeſtructible in cloſe veſſels, and prodigiouſly refractory, according to the experiment of Mr. Pelletier, made with balls of porcelain expoſed to the moſt intenſe heat.

Molybdena treated with the black flux was not reduced, nor even deprived of its ſulphur.

Molybdena fuſed with iron affords a button, which reſembles cobalt: it unites likewiſe perfectly with copper; but when mixed with lead and tin, it renders them ſo refractory that the reſults are pulverulent and infuſible alloys.

The oxide of molybdena obtained by calcination, or by the action on the nitric acid, is not reducible when treated with black flux, alkali, charcoal, or the other ſaline fluxes; nevertheleſs if the oxide of lead or copper be added, the metals which reſult are alloyed with a portion of molybdena, which may be ſeparated.

The oxide of molybdena made into a paſte with oil, dried by the fire, put into a lined crucible, and urged by a violent heat for two hours, afforded Mr. Pelletier a ſubſtance ſlightly agglutinated, which could be broken with the fingers. It was black, but perceptibly of a metallic aſpect. When viewed with the magnifier, ſmall round grains of a greyiſh metallic colour were ſeen, which are the metal of molybdena. It is prodigiouſly refractory; for the fire which Mr. Pelletier gave was ſtronger than that which Mr. Darcet uſed in the ſame forge to fuſe platina and manganeſe.

1. Molybdena is calcinable, and paſſes to the ſtate of a very white oxide. 2. It detonates with nitre, and the reſidue is an oxide of manganeſe mixed with alkali. 3. The nitric acid converts it into a white acid oxide. 4. The alkalis diſengage hydrogenous gas from it in the dry way, and the reſidue is the oxide of manganeſe and alkali. 5. It alloys with the metals in different manners. Its alloys with iron,

iron, copper, and ſilver, are very friable. 6. When treated with ſulphur it regenerates the mineral molybdena.

According to Mr. Kirwan, the mineral of molybdena contains fifty-five pounds ſulphur, and forty-five metal. The iron is accidental.

To reduce the mineral molybdena to powder, Scheele directs that it be triturated in a mortar with a ſmall quantity of ſulphate of pot-aſh. The powder is afterwards waſhed in hot water, to carry off the ſalt, and the molybdena remains pure.

This ore is a true pyrites, which, when treated with the blow-pipe, emits a white acid fume. But as this method affords only a ſmall quantity of oxide, another method is uſed to obtain it. Thirty parts of nitric acid are diſtilled on one of powder of molybdena; care being taken to uſe a large retort, and to pour the acid on at ſeveral times, having previouſly diluted it with one-fourth of water. The receiver being luted on, the diſtillation is performed on the ſand-bath. When the fluid begins to boil, a conſiderable quantity of nitrous gas comes over. The diſtillation being continued to dryneſs, there remains a powder, upon which an additional doſe of nitric acid is poured; and this management is repeated until all the nitric acid has been uſed. At the end of the proceſs there remains

mains a residue as white as chalk, which is to be washed with water to carry off a small quantity of sulphuric acid, which is formed by the decomposition of the nitric acid upon the sulphur. After this edulcoration there remain six gros thirty-six grains of an acid powder, when the operation has been made with thirty ounces of nitric acid, and one ounce of molybdena. It is the molybdic acid.

The arsenical acid distilled from the mineral molybdena, likewise affords the molybdic acid.

It is evidently seen that its formation, like that of the arsenical acid, is owing only to the decomposition of the acids made use of, and the fixation of their oxigene on the metal employed.

This acid is white, and leaves a perceptibly acid and metallic taste on the tongue.

Its specific gravity compared with that of pure water is 3,460 : 1,000, according to Bergmann.

It undergoes no alteration in the air.

It does not rise in sublimation, but by the assistance of the air.

It colours the native phosphate of a beautiful green.

If it be distilled with three parts of sulphur, the mineral molybdena is regenerated. This acid

acid is ſoluble in five hundred and ſeventy times its weight of water at a mean temperature. The ſolution is very acid; decompoſes the ſolutions of ſoap; precipitates the ſulphures of alkali. It becomes blue and conſiſtent by cold.

The concentrated ſulphuric acid diſſolves a large quantity of it. The ſolution aſſumes a fine blue colour, and becomes thick by cooling. This colour diſappears by heat, and returns again as the fluid cools.

The muriatic acid diſſolves a conſiderable quantity by the aſſiſtance of ebullition. If the ſolution be diſtilled, it leaves a reſidue of an obſcure blue colour. By an increaſe of heat, white ſublimate riſes mixed with a little blue; the fuming muriatic acid paſſes over into the receiver. This ſublimate attracts humidity, and is nothing but the molybdic acid volatilized by the muriatic.

This ſolution of the molybdic acid precipitates ſilver, mercury, and lead from their ſolutions in the nitric acid. It likewiſe precipitates lead from its ſolution of the muriate of lead, but not the other metals.

The molybdic acid takes barytes from the nitric and muriatic acids.

In the dry way it decompoſes the nitrate of pot-aſh, and the muriate of ſoda; and the acids paſs over in the fuming ſtate.

It

It disengages the carbonic acid from its combinations, and unites with the alkalis.

It even partly decomposes the sulphate of pot-ash by the assistance of a strong heat.

It dissolves several metals, and assumes a blue colour in proportion as it yields its oxigene to them.

The combinations of this acid with the alkalis are little known. Scheele however has observed, that fixed alkali renders this acid earth more soluble in water; that the alkali prevented the acid from rising; that the molybdate of pot-ash is precipitated by cooling in small granulated crystals.

The oxigene adheres but slightly to the molybdic base: for this acid boiled with the semimetals does not fail to assume a blue colour.

Hydrogenous gas passed through it is sufficient to produce the blue colour.

Molybdena, as Mr. Pelletier has observed, has a great resemblance in its chemical results to antimony; since, like that semi-metal, it is capable of affording by calcination an argentine oxide, capable of vitrification.

END OF THE SECOND VOLUME.